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# PRODUCT ENGINEERING

McGRAW-HILL WEEKLY FOR DESIGN ENGINEERS · JUNE 12, 1961

**en editors walked miles↑ report their observations of exhibits↓ and meetings in . . .**

REPORT ON THE 1961 DESIGN SHOW AND CONFERENCE... page 17

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# ROTARY OR CENTRIFUGAL

## ...Which one is best for your application?

Rotary or centrifugal? Sometimes the choice is easy. For example, you would use a rotary pump for very viscous liquids (over 2500 s.s.u.). Or where poor suction conditions exist. Or when positive displacement is required. Centrifugal pumps would be used for extremely corrosive or abrasive liquids, low viscosity liquids (under 2500 s.s.u.) water, slurries, or petroleum products.

But . . . in many applications combinations of these factors exist. Or the liquid you want to pump is not clearly in either area. Then there are other considerations such as initial cost, operating cost, lubrication value of the liquid, location and even budget limitations.

All of these considerations can put you in the middle—where either a rotary or centrifugal can be used. The best choice can only be made by someone with experience and knowledge of both types.

As one of the few manufacturers of a complete line of both rotary and centrifugal pumps, Worthington can help you select the best, most economical solution to this perennial pump problem. For the name and address of your nearest Worthington representative, consult the yellow pages.

P.S. If you'd like a copy of a 50-page booklet, "Rotary and Centrifugal Pumps: Theory and Design," please write to Worthington Corporation, Section 20-14, Harrison, New Jersey, for bulletin G-2666.

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PRODUCT ENGINEERING

McGRAW-HILL WEEKLY FOR DESIGN ENGINEERS

June 12, 1961 Vol. 32, No. 24

## FEATURED:

DEPARTMENTS:

INTERESTING TO NOTE 3
WHAT'S NEW IN RESEARCH 6
DEVELOPMENTS TO WATCH 8
FROM WASHINGTON 12
THE ENGINEERING WEEK 15
INDUSTRIAL DESIGN 26
READER TO EDITOR 28
MEETINGS 29
WHY NOT R&D 32
HORIZONS 55
PRODUCT DESIGN 65
DESIGN FILE 77
SIGNIFICANT COMPONENTS 80
DESIGN LITERATURE 95
REPRINTS 101
ADVERTISERS INDEX 102
READER SERVICE CARDS 103

**DESIGNING A SOLDERED ELECTRICAL CONNECTION** . . . H H Manko
Just how one handles this toughest of soldering problems..... 57

**PRESS-FORGE YOUR STEEL CASTINGS** . . . J T Berry, T Watmough
It's a hybrid process that improves strength and reliability..... 68

**WILL SOLID-FILM LUBES TAKE PUNISHMENT?** . . . B D McConnell
The latest on their ability to endure high temperature and vacuum.... 70

**HOW TO FILE IT—EFFICIENTLY** . . . R W Carson
With these practical methods are tips on saving time and space..... 74

**HOW TO LISTEN—AND REMEMBER** . . . E J Tangerman
Ten ways to be a bad listener—2nd article in a 3-part series..... 76

**FOR DEEPER THREADS IN SHEETMETAL** . . . F Strasser
They'll give a better grip; here's how to get them in thin metal..... 77

## FIELDS OF INTEREST REPRESENTED IN DEPARTMENTS:

MATERIALS:

**Here's more data** on beryllium..... 6
**Ozone-resistant butyl rubber** for low-cost parts..... 8
**Phenolic compound,** Orlon-reinforced, molds well in thin sections..... 80

MECHANICAL:

**Basic studies of wheels** are underway..... 6
**Miniature "thermal history"** gage is coming up..... 8
**Rotating-bellows seal** works at temperatures from —350 to 800 F..... 31

ELECTRICAL:

**Higher speed** for high-speed computers..... 6
**This transducer material** sports unusual properties..... 9
**Enameled capacitors** get high reliability rating..... 9
**Switch actuator** does work of two 180° cams back to back..... 80

PRODUCT DESIGNS:

**Controlled freezing** trims molded rubber..... 65
**It's a pushbutton** to safety..... 66
**Measures specific gravity** on the run..... 67

PROCESSES:

**Moving furnace sinters** long ceramics..... 8
**New machine** to perforate plastics and fabrics..... 8
**Melting point** controls oven temperature..... 9

GENERAL:

**Aftermath of war:** How we got Germany's shell-molding secret..... 3
**Aerospace industry** vies for contracts..... 12
**Cover story**—our staff reports the annual Design Show & Conference..... 17

# Adjustable From 1 to 15 Seconds

This new Allen-Bradley development should solve such occasional problems where, upon the operation of the push button or limit switch, a slight time delay should occur. Time delay is adjustable up to 15 seconds—and it can also be introduced when "stopping" the operation—but not in both the "starting" and "stopping" cycle.

Both push-button and limit switch are relatively low in cost—ideal for applications where a delay of only a few seconds is desired, and where the repetitive accuracy of the Allen-Bradley Bulletin 849 time delay relay is not necessary. Both units have single pole, double break contacts—either normally open or normally closed. They are no more difficult to install than the corresponding units without the time delay feature.

Machine tool and production system designers should have full information in their files on these new Allen-Bradley time delay push buttons and limit switches. It is yours for the asking. Write today.

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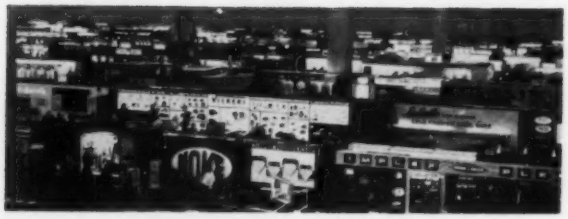
# INTERESTING TO NOTE



**On our cover**–Show time in Detroit's new Cobo Hall. More than 18,500 people filed through the aisles, viewing the more than 15,000 components on display–from micro-miniature lamps, circuits and screws to enormous beam sections and internal combustion engines. Over 400 companies participated in the exposition. Because the show was held in Detroit for the first time, the opening conference session was entirely devoted to design engineering in the automotive field. Representatives from the major auto companies discussed "Designing for Today's Competitive Market." A rundown of their views, plus a complete show report is on page 17.

## Secrets in Salt

Directly after World War II, American and British forces sent hoards of technical experts into Germany in hopes of uncovering some of their many secret industrial processes. One of the investigators for the Technical Intelligence Div of the U.S. Dept of Commerce was William McCulloch, Alabama-born and bred, but with a knowledge of the German language. He was sent to Essen to try and learn the German process used to salvage the thin coating of tin used on tin cans. The man who knew the process had adamantly refused to speak to McCulloch's colleagues, who spoke German fluently. But when the manufacturer heard his native language tempered with a Dixie accent he talked freely about his tin-recovery process. After McCulloch had gathered all the information, the manufacturer explained further why he wouldn't talk to the others. They spoke German like natives and might be former Nazis coming back to harass him; but the fellow with the southern accent just had to be an American.

McCulloch's next coup was tracking down a German named Johannes Croning, developer of a process called "das Formmaskenverfahren" or shell molding—by coating special molding sands with a phenolic resin a mold can be made which produces castings with a superior surface finish and close dimensional accuracy. (For an article on forged castings, see page 68.)

For this process, a team of investigators sifted through the files of the Krupp works, to no avail. Then, informers led the group to the Harz Mountains, where more than half a million pages of Krupp documents were found concealed in salt mines. In an adjoining mine was found the cache of secret patents buried by the German Patent Office. These documents led McCulloch to the location of Croning. He was living in Hamburg, working with a dozen other men in a small metallurgical laboratory. At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first, Croning was reluctant to discuss his process; however, with prodding he showed McCulloch how he could produce valve castings and cores. When Croning realized that his German patents were in public domain (as a result of agreements reached at the Potsdam Conference), he fully cooperated with the American agents.

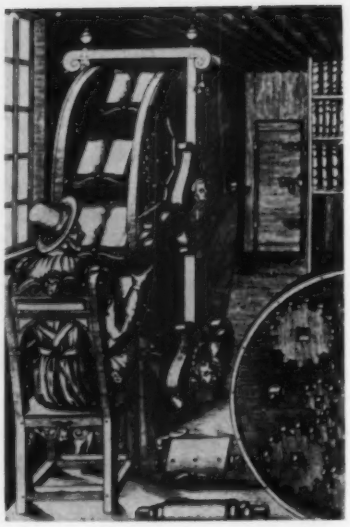
The shell molding process led to Croning's receiving the John A. Penton gold medal of the American Foundryman's Society in 1957.

## That Paper-storage Problem

As our technology expands, so does the paperwork. To launch a missile may require a ton of fuel, but before the missile is airborne at least a ton of letters, blueprints, memos, order forms, security documents, etc, have been written, mailed and stored. Record-keeping has long been an important part of business technology. Misfiling is a costly and wasteful part of the management bill; it results in time-loss to executives as well as to clerks. While costs for such misfiles vary with each type of business, Diebold Inc, manufacturers of filing equipment, has estimated that the average cost for each record temporarily misfiled is over $60—permanent loss of records brings much greater costs. The company also estimates that American businessmen spend $12 billion a year just to maintain records, employing over 9 million clerical workers to do the job.

Filing received its greatest headache when Gutenberg invented movable type. From then on, men could quickly reproduce copies of anything they wanted—copies that demanded more and more storage space. For several centuries there was no generally accepted system for filing. As nations grew, so did the amount of paper work. Thomas Jefferson, for example, wrote so many letters that, in self-defense, he invented an automatic signature—forerunner of today's rubber stamp. The result: more letters could be sent, more documents had to be stored.

The invention of the typewriter in the 19th century, and then the introduction of carbon paper, added more paperwork to be filed. One of the major developments in data storage was made by Melvil Dewey in 1872 when he suggested his decimal system for classifying books. He divided all his knowledge into ten categories of 100, from 000 to 999. He further subdivided these into tenths, hundredths and thousandths.



Early 15th century print depicts forerunner of today's rotary file. How widely it was used is not known, but since few could read or write, it was probably limited to the nobility and clergy. Note early use of wooden gearing.

Today's filing problems are near monumental. It has been estimated that the average company president receives 130 letters, memos and reports daily, and he files about 35% of them. Engineers, too, are burdened with numerous files. The article on p 74 presents some pointers on how to organize a personal filing system.

—Benedict A Leerburger Jr.

## NEXT WEEK IN PRODUCT ENGINEERING

. . . **Selecting Clutches for Mechanical Drives**

No longer mere switching devices, todays' clutches can do a multitude of power-transmission jobs. This procedure helps you pinpoint the type, location and size of the clutch you want.

. . . **Nonstandard Ratings for Integral-hp Motors**

NEMA standards haven't been updated for 30 years. Here's a suggested format for their revision.

. . . **Stresses When Curved Surfaces Touch**

Because their contact area is small, stress is high. Here are two factors that simplify finding the stress.

. . . **What Technical Problems Need Solving in the Primary-metals Industry?**

Representatives from the copper, titanium, beryllium and aluminum industries give their points of view.

*Complete ductwork system of new Humble Oil Building is . . .*

# GUARDED BY GALVANIZED STEEL

When this handsome Humble Oil office building in Houston, Texas, is finished in 1962, it will be the tallest building west of the Mississippi River. All 44 floors will be served by galvanized steel ductwork. That's 700 tons of skin-tight zinc-coated steel—a combination of tough durability and excellent corrosion protection with the broadest economy east *or* west of the Mississippi River. Galvanized steel's economy starts with fabrication, continues with erection and installation and is perpetuated in what little maintenance is required after that.

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# WHAT'S HAPPENING IN RESEARCH . . .

## *Higher speed for high-speed computers*

Closer attention to "secondary" factors in design of magnetic memories can do much to overcome the limitations now facing the big, high-speed computer systems, say Michael M. Stern and Herbert A. Ullman of Sylvania Electronics Systems. Among these factors: storage-element drive power requirements, self-heating and signal-to-noise ratio characteristics.

These are by no means the only limitations. Wires are long in the interwiring matrix of the big computers, and the transmission delay time may be appreciable. Reflections in the wiring may also result in unwanted ringing. "Cross-talk" between drive and sense wiring may complicate detection of stored information.

What can be done? To find out, Sylvania's researchers built a 0.8-microsec, 10,000-bit random-access core memory and now report that modifications in switching elements and core plane winding can substantially increase switching speed. Signal-to-noise ratios can also be improved.

Speed and power capability of semiconductor devices now limit drive-circuitry performance. But, say Stern and Ullman, "Studies have shown that if the timing of the multiplicity of circuits in a memory system is dependent on only a very few 'maser circuits,' it is possible to relax the specification on the largest part of the circuits and still achieve the high-speed operation."

## *More data on beryllium*

Beryllium reports, long held secret, are beginning to emerge from government laboratories. They provide needed design data on thermal and structural abilities of the material.

Latest released is a study made at Langley Field four years ago. Model nosecones, fabricated of pure beryllium and beryllium copper, were exposed to a 4000-F jet. Neither metal showed evidence of burning. But the beryllium was able to stay in the jet 2 to 4 times as long as the beryllium copper before it began to melt, and there was less than half as much ablation.

The Langley Field report, prepared by W. H. Kinard, also provides a useful comparison of thermal properties of the two materials:

Beryllium melts at 2343 F; beryllium copper at 1587.

Specific heats are 0.516 and 0.1 btu/lb/°F. Thermal conductivities: 0.20 and 0.16 btu/ft²/°F/sec.

Density figures point up another big reason for the emphasis on the pure metal: It weighs in at 0.66 lb/in.³ The alloy's density is 0.297.

(Note: For more information on beryllium and its alloys see *PE—Mar 17 '58, p 16; Dec 7 '59, p 39; June 20 '60, p 72.*)

## *briefs . . .*

**New thermocouple data,** including curves of temperature plotted against emf for many types of couples incorporating alloys of the platinum group metals; a table of properties of the platinum alloys; and pointers on calibration and use of thermocouples become available to US engineers in a hard-bound, 43-page illustrated book prepared by Johnson Matthey & Co Ltd. The latest edition, just published, can be obtained free of charge through JM's US office 608 Fifth Ave, New York 20.

**The "spectra of science"**—not just the light spectrum, but also the electromagnetic spectrum, the temperature spectrum, the radio-TV spectrum, the sonic "spectrum," and even the geological time "spectrum"—are charted in a full-color wall-size chart (it folds to pocket size for convenient carrying) prepared by the Atomic, Physics & Science Fund. A companion piece to the Fund's periodic chart of the elements (*PE—May 30 '60, p 9*), it's available free of charge to PE readers from Columbian Financial Corp (manager of the APS Fund), 1033 W 30th St, NW, Washington 7, DC.

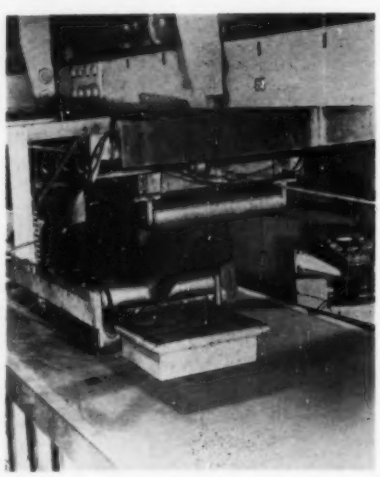
**More high-purity metals** become available for research as Asarco adds nine more to the group it's offering at 99.999% purity on an "off-the-shelf" basis. The newcomers: antimony, arsenic, bismuth, cadmium, gold, indium, silver, and tellurium. Previously available: copper, lead, thallium, and zinc. About half are sold in pound lots; the rest in grams and ounces, with prices (except for the precious metals) ranging from $5 a pound (for bismuth) to $30 (for tellurium).

Data sheets are available through the company's sales offices. **—ARG**

## *Basic studies of wheels underway*

How does terrain influence movement? What is the optimum wheel design for specific soil conditions? A lot of laboratories are working on these problems. One of the newest and best-equipped: Army Engineers' Mobility Research Center at Vicksburg, Miss. It has a remarkable array of soil-preparation and testing equipment, instrumented traveling cars, and a mobile carriage on which vehicle models can be mounted (see photo).

Information is being collected on the dynamic variables of speed, horizontal force, sinkage, slippage, rolling resistance, tractive effort, and a host of other factors; and reports will be made available for general engineering use. The Center itself is open weekdays for public inspection and visitors are welcome.



**MODEL WHEELS** are mounted on aluminum carriage at Mobility Research Center. Vertical and horizontal loads can be applied; and measurements, converted into electrical signal analogs, are transmitted through cables to an instrumentation center.



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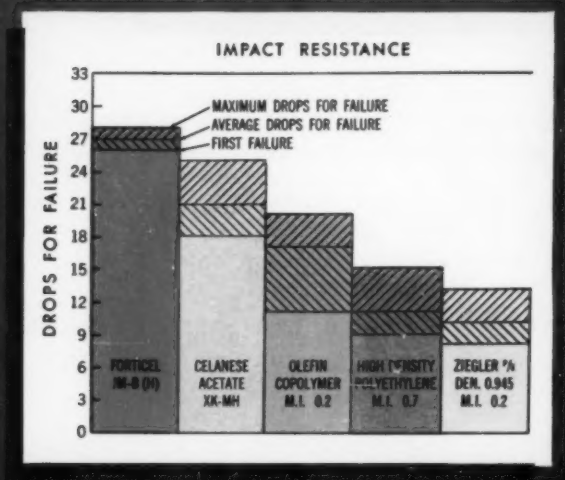
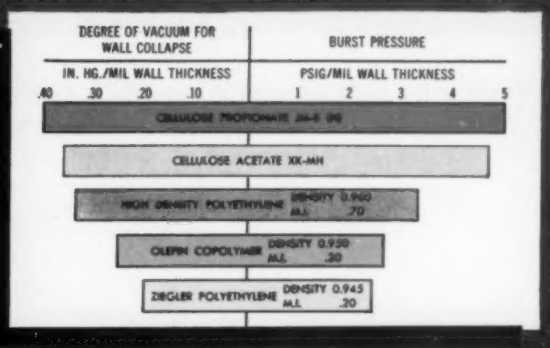
# CELANESE POLYMER COMPANY

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# DEVELOPMENTS TO WATCH...

## *Miniature "thermal history" gage coming up*

A gage no bigger than a dime, which can be attached to motors, turbines, and other equipment to record service time at specific temperatures, is in the development stage at Ilikon Corp, Natick, Mass.

The gage consists of a bundle of fine wires, held in an electrically insulated frame. Composition of the wires is such that their electrical resistance will change on a predictable basis with time and temperature. This change records the thermal history of the machine to which the gage is attached. Ilikon says it requires no outside electrical connections, can be used in any environment in the 1300 to 1800-F range.

Working models have been built, but Ilikon emphasizes that much work remains to be done before the unit is ready for marketing. Target date for commercial introduction is the end of this year.

## *Ozone-resistant butyl for low-cost parts*

A butyl rubber "with greater ozone resistance than any other commercial general-purpose rubber" and the ability to accept large quantities of fillers and plasticizers is being readied for market.

Esso Research & Engineering, which developed the new polymer, believes its ability to accept large amounts of fillers and plasticizers should enable production of finished parts at unusually low cost. Expected applications range from electrical insulation and weatherstripping to foamed and molded parts.

The material is now in pilot production and samples are available from Enjay Chemical, which will market it.

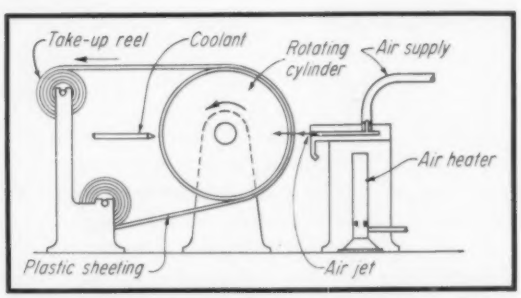
## *Moving furnace sinters long ceramics*

A reverse twist on the usual sintering procedure is helping United Kindom Atomic Energy Authority produce sintered ceramic parts of almost any length. It's much like a zone-refining technique in which a heater—and therefore the sintering zone—travels along the compact, rather than the reverse. Contraction of the heated zone does result in necking of the compact, but there is no cracking if the process is carefully controlled.

Furthermore, say J. E. Antill and Henry Lloyd of UKAEA, for a given temperature and rate of furnace motion, the final density is reproducible. A description of the process is contained in British Patent 848,571.

## *New machine to perforate plastics and fabrics*

A novel method for producing perforated plastic sheeting and also providing heat-sealable areas has been devised by Kendall Co engineers. It's a process which turns prescribed areas of crystalline plastics—Mylar, Saran, Kel-F—into amorphous regions that melt at lower temperature, can be heat-sealed, and are readily perforated.




**SHEET PERFORATOR** consists of rotating cylinder with perforated surface which serves as film support, plus reels and jets. Here, air is the hot fluid. Process may be applied to fibrous materials as well as film.

A stream of hot fluid (liquid or air) is directed across the sheet while it's supported on a perforated, heat-conducting base. In the areas where the sheeting touches the conductive material, the plastic is kept cool and retains its crystalline structure. But in the unsupported areas, it heats, softens or melts, and holes are made.

Best results are obtained with jets at between 500 to 1700 F and film speeds from 12 to 100 fpm (depending on type of film and whether it is to be softened or melted).

## This transducer material sports unusual properties

A ferroelectric with an unusually high transition point (above 1200 F) is being developed by Westinghouse research labs. The material: bismuth titanate. It's closely related to the well-known piezoelectric barium titanate; but has valuable characteristics of its own.

The compound itself is not new; but earlier investigations failed to uncover its ferroelectricity—probably because measurements were not extended to the very high Curie (transition) point. However, E. C. Subbarao of Westinghouse reports that it has a definite dielectric constant peak and shows a definite hysteresis loop.

The material is not yet available commercially. But it has been made in both single-crystal and in polycrystalline form; and its high transition point and low lattice distortion, which recommend it for high-temperature transducers, are encouraging further work.

## Enameled capacitors get high reliability rating

Solid-state capacitors with new vitreous enamel compositions as the dielectric material are showing failure rates as low as $2.4 \times 10^{-6}$ per thousand hours, says A. S. Takacs of Vitramon Inc, Bridgeport, Conn. And, he says, tests now in progress are expected to demonstrate failure rates on the order of $10^{-7}$ per thousand hr at 200 C with a test voltage of 50 v dc.

Furthermore, he claims, these capacitors show practically no electrical drift. At room temperature, insulation resistance of 1000-pf units is $10^{14}$ ohms and dissipation factor is 0.000,35. Even at 250 F, insulation resistance is $5 \times 10^{10}$ ohms; dissipation factor, 0.0015. Room-temperature tests after 2000 hr at 250 F with 150% of rated voltage applied, show virtually no change in the original values. Insulation resistance returns to $10^{14}$ ohms and dissipation factor to 0.0035, with a capacitance change of less than 0.05%.

A preliminary report on the capacitors was presented at the Electronic Components Conference, and Takacs says prototypes are now undergoing military qualification and other tests as part of a long-term reliability rating program, expected to be completed late this year.

## Melting point controls oven temperature

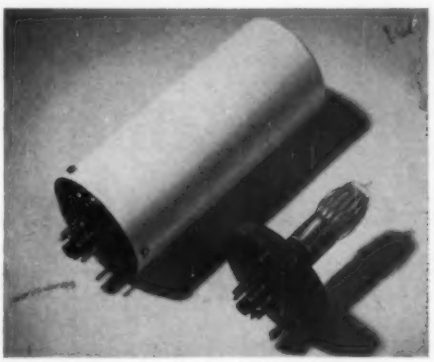
A constant-temperature oven with a novel means for turning itself on and off has been designed by D. J. Fewings of Marconi's Wireless Telegraph.

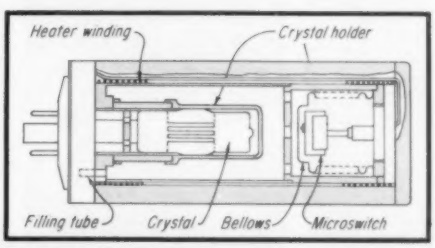
The basic principle is simple: The component to be maintained at a constant temperature, and a heater coil, are embedded in a material which expands as it melts and activates a switch that turns the heater on and off.

As long as heat input is less than or equal to heat loss, current flows to the heater. When input exceeds output, and the system temperature begins to rise, the solid melts, expands, compresses the bellows and hits the switch.

In the unit pictured, naphthalene (melting point, 175 F) is the active material. It meets the temperature requirements for the crystal oscillator and has the advantage of "adjustability" (adding anthracene can vary its melting point by about 6 deg) and a rather large change in volume on melting—over 10%. However, other compounds can be used.

Fewings says the change of internal temperature can now be held to about 1/173 of the change in external temperature, and it can be improved.—ARG






**CONSTANT-TEMP OVEN** for crystal oscillator is pictured above, with crystal and crystal holder. Diagram shows oven construction. Naphthalene surrounds crystal holder, presses against bellows chamber as it expands and activates the switch.

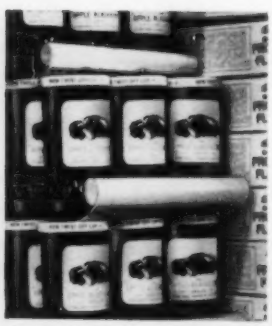
# Tough, durable Mylar® cuts costs... improves product performance

For example, "Mylar"* polyester film gives many products extra resistance to chemicals, moisture and aging . . . lengthens their life. Today, "Mylar", with its high tensile strength in thin gauges, is improving the performance of products as different as wire and cable tapes and loose-leaf-sheet protectors.

Can this unique plastic film and products made with it help you? For more information on "Mylar", write the Du Pont Company, Film Dept., Room S-8, Wilmington 98, Delaware.

**1.** Conveyor belts of "Mylar" are easy to install, need fewer replacements, are easy to keep clean . . . cut "downtime," reduce costs.

**2.** Age-resistant recording tapes of "Mylar" won't ever dry out or get brittle . . . are highly stretch- and break-resistant . . . assure lasting fidelity.



**3.** Roll-back shelving of "Mylar" gets rid of retail stacking and stocking headaches. As shoppers remove items, "Mylar" rolls back.

DU PONT
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*"Mylar" is Du Pont's registered trademark for its brand of polyester film.

Better Things for Better Living . . . *through Chemistry*

DU PONT
**MYLAR**
POLYESTER FILM

# Self-Aligning ball bearings by Link-Belt

## Reasons why Link-Belt ball bearings are "first choice" with design engineers

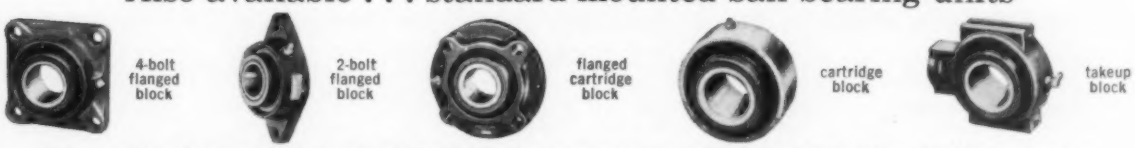
- **LONG LIFE**—Self-aligning, precision, deep-groove, single-row ball bearings provide highest capacity for radial or combination radial-thrust loads.
- **SMOOTH, QUIET OPERATION**—Honed to a micro-finish, raceways and precision balls minimize friction.
- **IMPERVIOUS SEALS**—Provide positive grease-in, dirt-out protection to assure full bearing life.
- **SIMPLE INSTALLATION**—Steel collar locks bearing securely to shaft. Slotted bolt holes facilitate mounting.
- **MINIMUM HEADROOM REQUIRED**—Pressure relief fitting is mounted at 45° from vertical . . . makes it easy to lubricate in close-clearance applications.
- **VARIETY OF HOUSINGS**—Types and sizes for *every* application.

**BALL BEARING PILLOW BLOCKS WITH ONE-PIECE HOUSINGS**—Series 200 and 300 pillow blocks for ½" to 4" shafts. Most popular housing design! Lubricated . . . ready for installation.

**BALL BEARING PILLOW BLOCKS WITH HEAVY-GAUGE PRESSED-STEEL HOUSINGS**—Low-cost Series JPS-200 pillow blocks for ½" to 1-7/16" shafts. Completely assembled, ready to install . . . lubricated for life.

**BALL BEARING PILLOW BLOCKS WITH TWO-PIECE HOUSINGS**—Series 200 and 300 pillow blocks for 1⅛" to 3-15/16" shafts. Large lubricant reservoir for oil and grease lubrication.

## Also available . . . standard mounted ball bearing units




For complete information on this all-inclusive line, contact your nearest Link-Belt office. Write for catalog.

**LINK-BELT**

15,642

**MANUFACTURERS OF SELF-ALIGNING BALL AND ROLLER BEARINGS**

**LINK-BELT COMPANY:** Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Warehouses, District Sales Offices and Stock Carrying Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs; Switzerland, Geneva. Representatives Throughout the World.

# FROM WASHINGTON . . .

## *Aerospace industry vies for contracts*

When Pres Kennedy publicly put the US into the race with the Soviets to be first to land a man on the moon, he touched off a scramble among the big aerospace contractors to get the Apollo contract.

**The reason is simple. Cost of the program will run into billions of dollars. And now that US prestige in space is tied directly—and openly—to winning the race, contractors know that there will be no lack of money flowing into the project. Estimates are that it will cost anywhere from $20 billion to $40 billion to put a man on the moon.**

Contractors are coldly calculating how to win the contract. It goes beyond sheer technical ability and plant and managerial capacities. The added ingredient of politics is being rated high in the maneuver.

**Some companies privately reveal that they are purposely not bidding on some contracts now so that they won't already have large space contracts when the time comes to award Apollo.** The reason is semi-political. They can argue for a spread in the space dollar, a factor that may be sufficient to swing the contract their way.

**Production contracts for the big Saturn booster's first and second stages will be let by the National Aeronautics and Space Agency late this summer or fall.** Although these contracts will be multimillion-dollar in size, some companies will pass them. They want to be in a better position for Apollo—size of its contract over the several years makes the gamble worth taking.

## *Navy announces radical ship designs*

A new fleet of radically designed naval research ships has been announced. Ships of the future include high-speed hydrofoil craft operating up to 90 knots as troop-landing craft and antisubmarine vessels; hydroskimmers on the air-cushion principle operating in the 100-knot speed range and weighing several thousand tons, for virtually all kinds of naval uses.

**Along with the over-the-water fleet of vessels under development, ships that plow deep into the ocean and surface vessels that submerge are being developed. Under consideration are ships with bottoms extending down to 160 feet. The purpose here is to get submarine detection equipment deep down into the water for better operating efficiency.**

Navy designers have also come up with submersible aircraft carriers and landing craft as a method to escape detection.

**New submarines to operate far below the ocean surface are under development.** An experimental vessel in the shape of a cylinder with ends closed by hemispherical heads will be used by Navy as a forerunner of future submarines.

## *Navy describes oceanographic program*

A new 10-year oceanographic program to cost nearly $1 billion has been laid out by Navy. **Called Tenoc-61, to denote the updating of the original 10-year Tenoc plan, here is where the money would go over the 10-year period:** surveys, $128 million; forecasts, $18 million; information dissemination, $12 million; military oceanography, $245 million; new ships, $229 million; instruments, $46 million; facilities, $18 million; and basic research, $210 million.

# 5 REASONS FOR SPECIFYING U.E. INDICATING TEMPERATURE CONTROLS

✱ **HIGH SENSITIVITY**...on-off differentials from ± .5° F with excellent repeatability

✱ **LOW COST** . . . list prices from $35.00 with generous quantity discounts

✱ **EASY MAINTENANCE** . . . thermal assemblies quickly replaced in the field with no loss of calibration accuracy

✱ **PROVEN DEPENDABILITY**... reliable liquid-filled measuring systems combined with simple service-proven components for accurate performance and long life

✱ **GREATER VERSATILITY**... many styles, ranges, sensing elements and switch characteristics permit hundreds of "custom-built" combinations

**ALL PURPOSE**

**-150° to +650° F**

A sensitive wide range unit with control point accuracy equivalent to individually calibrated instruments. 10" rotating scale permits unusual readability and close settings. Available with dual switches for controlling two independent circuits.

E 32N

E 36N

**LOW COST... (800 Series) -150° to +650° F**
Short dial spans of 50 to 200° F permit compact design only slightly higher in price than non-indicating controls. Available with dual switches.

**HIGH TEMPERATURE . . . (900 Series) 0° to +1000°F**
A NEW high temperature series with rugged stainless steel mercury filled thermal systems.

**For the USUAL or UNUSUAL application, United Electric offers quality controls at economical prices.**

E 65N

**SPACE SAVING... -150° to +650° F**
Skeleton design permits direct incorporation into equipment – saving cost of enclosure. Many models with dial spans of 50 to 200°F. Available with face plate for panel mounting.

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**SPECIAL PURPOSE . . . -150° to +1000°F**
Shown here is a typical Special Purpose control used on medical equipment, such as baby incubators, etc. WHAT IS YOUR REQUIREMENT? Chances are one of our standard controls will satisfy your needs. If not, we'll put our 30 years' experience to work for you on special designs.

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GOODYEAR

# EXCLUSIVE! GOODYEAR GREEN SEAL V-BELTS

## to give you sets that are precision-matched in length to outperform...and outlast...all others

*At no extra cost,* GREEN SEAL *V-Belts also give you:*

**Dimensional stability** throughout the life of the belts via highly shrink- and stretch-resistant 3-T Process Cord or airplane-type steel cable.

**Protection against dampness** through special mildew-inhibited rubber compounds.

**The most complete line** of V-Belts in the industry—easily and quickly available through our nationwide network of distributors.

**Still another "plus":** The G.T.M.—Goodyear Technical Man—is available to help you select the right belts for any drive.

**For your best buy in multiple drive belts**—including new money- and space-saving HY-T Wedge V-Belts—look to Goodyear. Also, get the full story on P.D. (positive drive) Belts and Variable Speed Belts from your Goodyear Distributor. Or write Goodyear, Industrial Products Division, Akron 16, Ohio.

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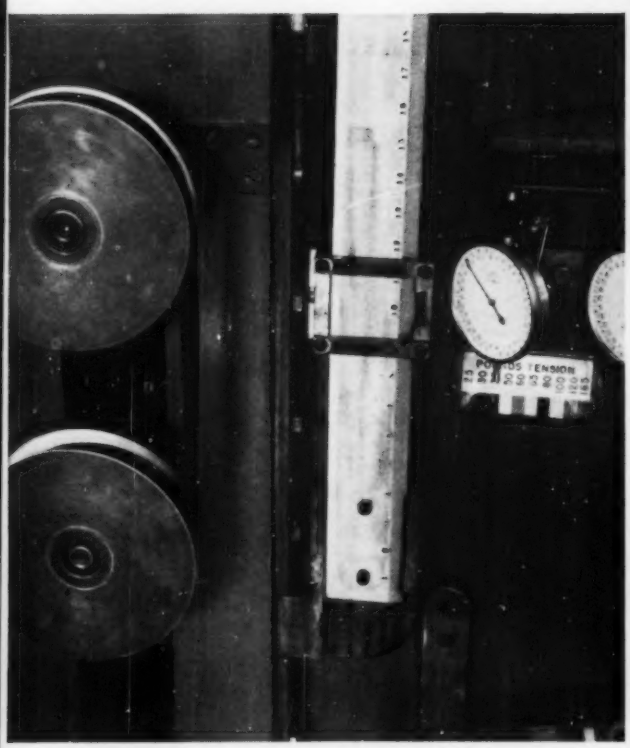
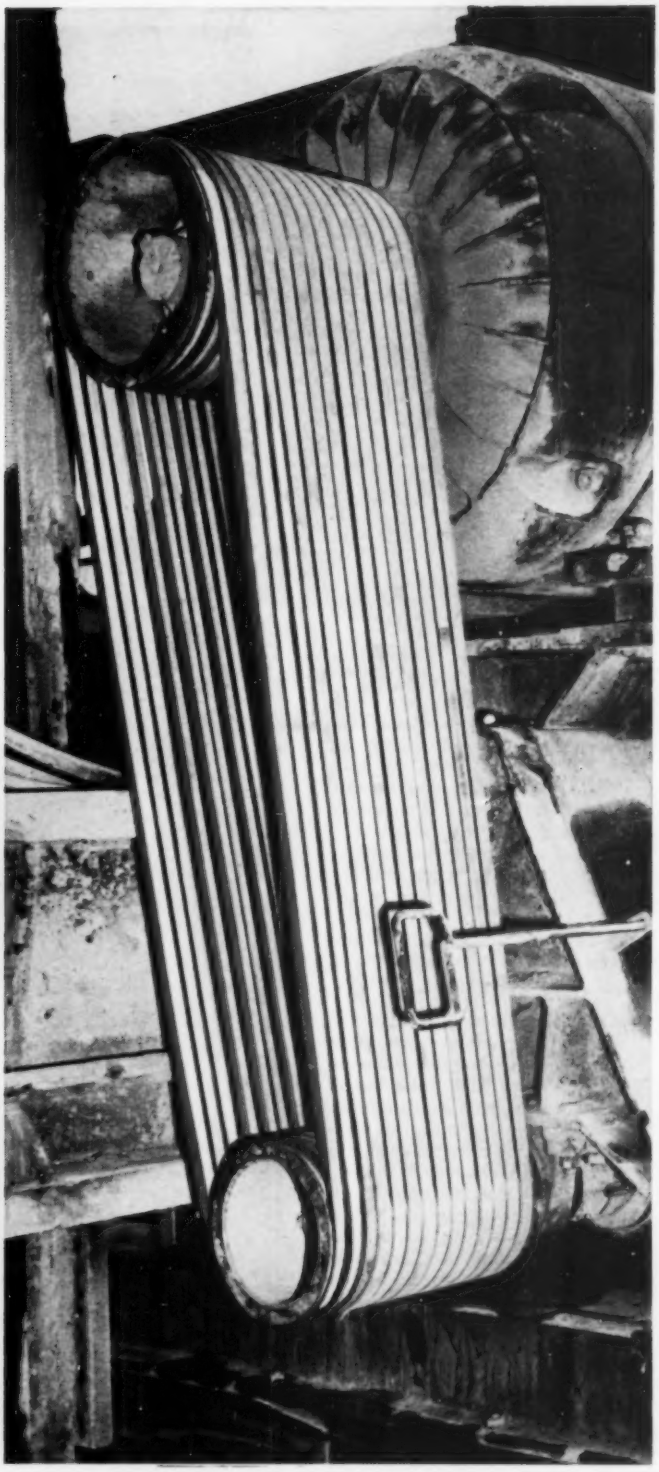
GOODYEAR INDUSTRIAL PRODUCTS

Compass, Green Seal, Hy-T, P.D.—T.M.'s
The Goodyear Tire & Rubber Company, Akron, Ohio

# CODES TO 1/32"...



**Length-coding GREEN SEAL V-Belts to 1/32"—not just 1/10" like most belts**—takes this ultra-precision machine. *Only* Goodyear has this type of equipment, which is set by means of fine-tolerance steel templates to insure accuracy.



**Harnessing this big, 22-saw stonecutter for 3 full years** required COMPASS-V-Steel Belts by Goodyear. Over this period, the Goodyear belts helped carve up 20 tons of rock a day—over 15,000 tons in all. Normal V-belt life in this type of rugged service is a scant 6 months.



CIRCLE 15 ON READER SERVICE CARD 

# R B&W FASTENER BRIEFS

RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY

## *Technical-ities*

By Fred E. Graves

### Fastening of "blind hole" joints

Holes which don't go all the way through a solid member must be tapped, of course. In shallow, small holes, in non-critical fastening, and in soft materials thread cutting screws work well and save time.

But fastening large flanges, pressure plates, heads and the like to costly castings needs more precise production. These holes are ¼" diameter and larger, affect design strength.

#### THREAD EFFECTS

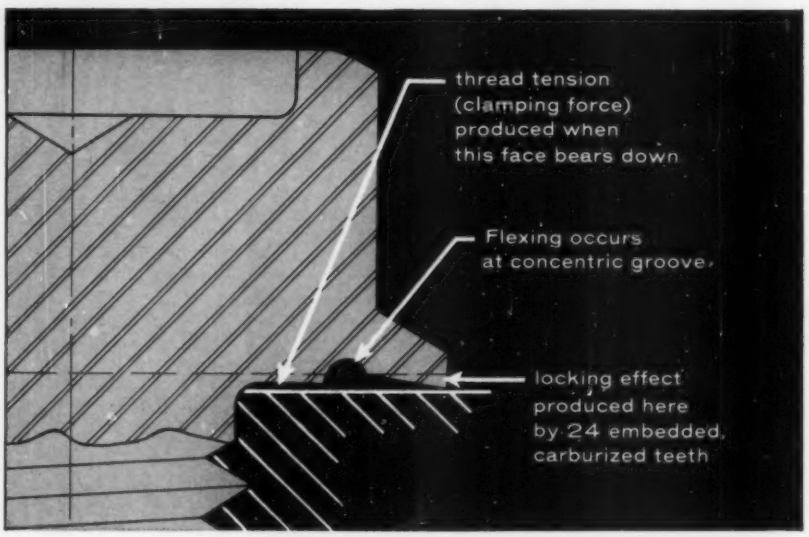
Such holes are coarse threaded. The coarse threads develop more thread strength than do fine threads, also take fewer turns in assembly. Studs go into the holes with an interference thread fit; hex screws with a simpler clearance fit.

Desirably, studs should all be driven to same depth and bottomed. Because of normal manufacturing differences, various mismatched high and low tolerances will cause studs to project unevenly. Assemblers often have to juggle. No such problem exists with hex screws. You just tighten to specified preload. And there's no double driving operation, as with stud plus nut.

#### STRENGTH OF BLIND JOINTS

Tapped holes behave like nuts. Their threads adjust elastically and plastically to distribute stress and develop high thread tension. Is this harmful in repeated disassemblies? Not at all. Hex screws have been installed 50 times in cast iron test blocks, then tightened to failure without damage to tapped holes.

# Clamps like a hex screw Grips like an anchor


thread tension (clamping force) produced when this face bears down
Flexing occurs at concentric groove
locking effect produced here by 24 embedded, carburized teeth

**Tensilock**® screws offer you the ideal combination of high clamping force and high locking power.

While a standard high strength hex screw can be tightened to a higher thread tension, its off-torque is less than its on-torque.

#### ANCHORED IN PLACE

The *"Tensilock"* screw features ratchet action teeth formed at an angle which will cut driving effort to permit you to utilize more of the full strength of screw. At equal driving torque, it not only develops 90% of the strength of a high strength hex screw but also takes *25% more torque to loosen than to tighten.*

Because of the flange's concentric groove, it flexes, allows the screw to bear down solidly on its seat and develop a high level of thread tension. At the same time the teeth embed themselves, are aided in maintaining their grip by pressure of the spring-action flange.

#### MAKES GOOD FRICTION-TYPE JOINT

Clamping force from Tensilock fasteners is sufficient to prevent slippage of fastened members where holes are oversize or eccentric. Grip of the teeth keeps fasteners tight under conditions of vibration or cyclic temperature changes. RB&W *"Tensilock"* Nuts also available. Write for Bulletin TL-2. Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, New York.

® Registered and Patented

Plants at: Port Chester, N. Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional sales offices at: Ardmore (Phila.), Pa., Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

# THE ENGINEERING WEEK

## This Year's DESIGN SHOW AND CONFERENCE

**I—THE CONFERENCE:** **Automotive executives discuss the country's most competitive industry. They field and fumble some pointed questions from the floor. Others cover electric vs hydraulic motors, powder-metal part design, adhesives, and some predictions for the future of filament winding.**

DETROIT—America's auto engineers are working on the warranted 100,000-mi car, some 1000 design engineers were told here at the opening session of the ASME Design Engineering Conference at Cobo Hall. Manufacturers are reviewing their automobiles part by part to eliminate potential trouble spots, said Will Scott, in charge of Ford's central product planning office.

"We realize that the cost of making a part right in the first place is only a small fraction of the cost of replacing or repairing it after the car is sold," he went on. "It is industry's responsibility to minimize the cost of maintenance and we are making progress that the public can feel in its pocketbook."

Scott insisted that there is no consumer "rebellion" against Detroit's product. American manufacturers, he said, can beat foreign competition without tariff protection, as the recent introduction of compacts has shown.

The single automobile is no longer a status symbol, Scott concluded. "The number of cars a family owns is now the test. The really affluent family is the one that has so many cars it occasionally misplaces one."

Carl E Burke, chief development engineer, American Motors, said the popularity of compact cars is in their low maintenance cost. He said the automotive suppliers are making the greatest contribution to design. "They are specialists in their own fields and component parts they design determine the quality of the car."

Herbert Bevans, executive engineer, Chrysler, warned that the increasing use of salt to melt snow, together with unitized construction of cars, presents a major corrosion problem. American manufacturers, he said, are trying to deal with the problem so that "cars do not rust and fold up in the middle."

Commenting on model changes, Bevans added that "although engineers thrive on change, automobile companies resist change for change's sake. Any improvement must improve car reliability and interest new customers."

Also speaking about model changes, Conrad F Orloff, assistant chief engineer, Chevrolet, pointed out that intense competition within the industry required that companies stay abreast of the market by having the latest in design.

"To stay competitive, a manufacturer needs a shorter lead time from planning to production, in order to incorporate improvements. At the same time lead time cannot be too short or crash programs will force tooling costs and car prices too high," he said. —Robert E Abbott

#### OTHER CONFERENCE HIGHLIGHTS

**Hydraulic motors are preferred over electric motors** because of their much higher torque-to-inertia ratio and faster response, insisted Robert K Sedgwick, Kearney and Trecker. The problems with hydraulic systems are: their sensitivity to fluid contamination, to heat, pressure surges, and the generation of noise. Sedgwick advises:

- Put filters in bypass lines to avoid surges.
- Flareless fittings are preferred to flared fittings, at least for the $\frac{3}{8}$-in. size, because of their better dependability.
- Higher pressures (over 3000 psi) allow the use of smaller tubing which

> ***"Good engineering or good styling is engineering or styling that can be sold at a profit."***
>
> ***—Will Scott, Ford Motor Co***

is mechanically almost as strong as solid rod.

• Hydraulic motors are usually overpowered for acceleration reasons. Valve failure may then put full pressure on a jammed cylinder and apply over 100,000 lb trust on a machine member.

Electric motors have problems too, said Frank C Rushing, Westinghouse Electric. Most users want a standard motor regardless of cost or temperature capability (a special might cost less in some instances) because they fear a breakdown and later replacement problems, he said. Further, users object to a motor that feels hot even if it has been specifically designed to operate at that temperature. Rushing suggests a psychological trick —put ribs on all high-temperature motors to reduce area of contact and apparent temperature.

**Reducing cost of powder-metal parts** requires a practical understanding of the limitations imposed by the process. Paul J Failla, Johnson Bronze Co, gave rules for improved quality and reduced cost. Shape of the part must be such that:

• It can be ejected from the die,

• Powder is not required to flow into narrow splines or sharp corners,

• It permits construction of strong dies and punches,

• It has as few levels as possible.

• Die friction limits the length to which a thin-walled part can be pressed. Maximum length is about 2½ times the diameter of the cylinder.

**Elastomer-resin film-type adhesives** that require very little pressure between mating surfaces during cure are the latest development in structural adhesives, according to W C O'Leary of 3M. Film adhesives, though expensive, are gaining in popularity because they are 100% solids and easy to handle. Tensile and shear strengths are in the order of 10,000 psi, and much strength is retained at temperatures as high as 350 F.

Factors influencing performance of metal-to-metal adhesives, according to H R Butzlaff of A O Smith Corp include: overlaps, metal thickness, temperature, film thickness, joint geometry, rate of loading, exposure conditions. On this last point, Butzlaff indicated that water immersion apparently affected epoxy adhesives more than nitrile-phenolic types. Further, re-baking under vacuum brought strength of nitrile-phenolic back up to 100%, sometimes beyond this, while the same technique restored epoxies to only 50% of full strength. Test work at A O Smith has shown that 72 hr in boiling water is a good accelerated test for comparing adhesives for water resistance.

Other points of interest:

• Machining an assembly after bonding can injure the joint, either because of cutting loads or heat set up in the material.

• Sand blasting the metal before bonding serves solely to clean the metal and does not materially assist the bonding process.

• The upper temperature limit for organic adhesives remains about 500 F.

• Weather exposure and water immersion are factors receiving close attention.

*"Automobile engineering and styling changes are vital to interest new customers and improve reliability."*
*—Herbert M Bevans, Chrysler Corp*

**Filament winding** is still almost exclusively used in pressure vessels, with main emphasis in defense, according to Richard Gorcey, Rocketdyne. Storage tanks for corrosive fluids have been made by filament winding, but the main interest in the process is directed at promised high-temperature filament materials. A composite stress level in the range of 300,000 psi is expected in about five years. In the more hazy future Gorcey predicts eventual use of whisker materials in filament windings, especially carbon whiskers, with a strength level of 850,000 psi, a modulus of elasticity in the range of $85 \times 10^6$ and a density of only 0.061 lb/cu in.

## Product Engineering presents Master Design Awards

DETROIT—A ¼-in. drill, a TV camera, a two-speed bicycle transmission, a mass spectrometer, were among the nine products honored by PRODUCT ENGINEERING during the Design Show. Second Annual Master Design Awards, for achievement in product development, were presented by E. J. Tangerman, editor, at a luncheon in the Detroit Athletic Club May 24.

"It is our intention to recognize the contribution made by individual engineers and designers despite the trend toward anonymous committee action and mass-attack research and development," said Tangerman.

Winning companies were: Knox Instruments Inc, Seattle, Wash; Bausch & Lomb Inc, Rochester, NY; KIN TEL Div, Cohu Electronics Inc, San Diego, Calif; Consolidated Electrodynamics Corp, Pasadena, Calif; Eclipse Machine Div, The Bendix Corp, Elmira, NY; Motorola Inc, Franklin Park, Ill; Disston Div, H K Porter Co Inc, Philadelphia, Penna; Radson Engineering Corp, Macon, Ill; Smith-Corona Marchant Inc, New York, NY.

Detailed descriptions of the winning products appeared in *PE—May 22 '61, p 35.*

**DESIGNERS OF THE COMPACT ELECTRIC TYPEWRITER** receive their certificates from Editor Tangerman. D. O. Chase and P. H. Stevens, left, were consultant industrial designers on the job. A. C. Zeamer, manager, production engineering, J. Barkdoll, chief project engineer, and R. Metzner, staff designer, industrial design dept, surround E. G. Moshier, vp engineering, Smith-Corona Marchant Inc.

# Ten editors looked and listened

**II—THE SHOW:** New ideas were plentiful—though many were hidden. "Not quite ready to release," they said, "but since you asked . . ."

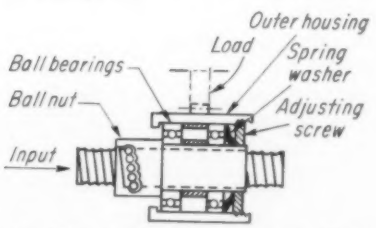
## MECHANICAL COMPONENTS

**Precision racks for instruments and servos . . .**
are made to new standards, equivalent in accuracy to AGMA's Precision classes for gears. Available from stock in lengths to 11 in., the racks, from PIC Design Corp, East Rockaway, NY, are supplied with a "certified" inspection trace showing deviations in tooth-to-tooth and maximum overall error. Racks may be butted for greater lengths and adjusted linearly by meshing with another rack upside down and locking the butted racks. Available with 20° pressure angle, diametral pitch from 24 to 96, and made of 2024-T4 aluminum or 416 stainless material. The newly established tolerances are:

| PIC Class Rack | Adjacent Tooth-to-tooth Error | Non-adjacent Tooth-to-tooth Error | Max Overall Accumulated Error to 11 in. |
|---|---|---|---|
| PREC. 1 | 0.0005 | 0.001 | 0.002 |
| PREC. 2 | 0.0004 | 0.0007 | 0.001 |
| PREC. 3 | 0.0002 | 0.0005 | 0.0006 |

**Innovations in antifriction screws . . .**
give improved torque-limiting and position-locking characteristics. The torque-limiting device (see sketch) is a development of Saginaw Steering Gear Division, Saginaw, Mich. The pair of ball bearings are preloaded by tightening the spring washer so that it takes, for example, 10 in.-lb of torque to rotate the bearings. Linear positioning of the screw will cause the nut, the outer housing, and the load (which may be a gear train) to rotate as one unit—providing the load does not exceed 10 in.-lb. Above this amount the bearing will rotate causing the nut to idle while the housing and load remain stationary.

Another development is a one-way braking system

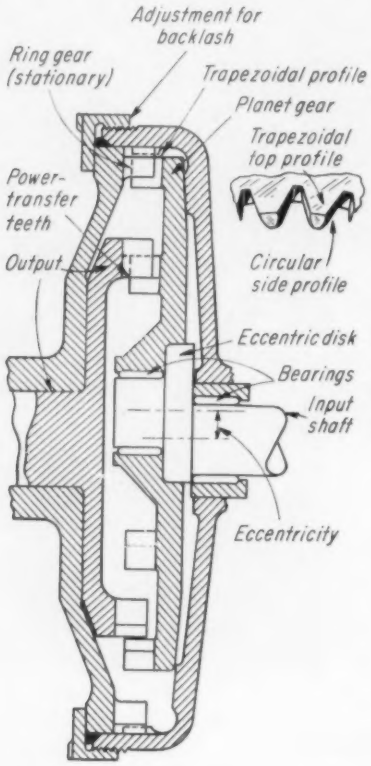



developed by The Anderson Company, Gary, Ind, for their Roton bearing screws. The device employs an internal friction-disk brake to lock the nut to the screw. To move the screw, say to the right, a cam-release lever must be actuated. This separates the friction plates, permitting infinite positioning in that direction. However, moving the screw to the left automatically releases the brake. The device is now being applied to a reclining seat mechanism in buses.

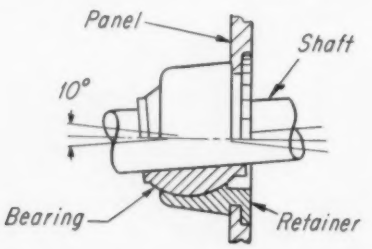
**Two-gear planetary system for high reduction . . .**
employs special-contour teeth to take up backlash. Developed by Gleason Works, Rochester, NY, the system differs

from that of a typical three-gear planetary in that the sun-gear is replaced by an eccentric disk. The planet gear can be made almost as large as the ring gear, permitting higher ratios.

Rotation of the input causes the planet to "walk" around inside the ring gear. Because the center of the planet describes a circle, a second set of teeth are needed to transfer power to the output. The teeth have circular side profiles for extra strength (there is no generation), and trapezoidal top profile to permit axial positioning for eliminating backlash.




**Self-clinched spherical bearings . . .**
of Delrin offer a new method for low-friction support of light-duty shafts or long push rods. Developed by Spyroflo, Inc, North Miami Beach, Florida, a newly formed division of Penn Engineering, the bearing is pressed on to sheet aluminum or steel with a punch using same technique as for clinch nuts. It can be replaced in same hole at least three times, and takes 10° shaft misalignment. Retainer is 2042-T4 aluminum or 303 stainless. For shafts 3/32 to 1/4 dia.

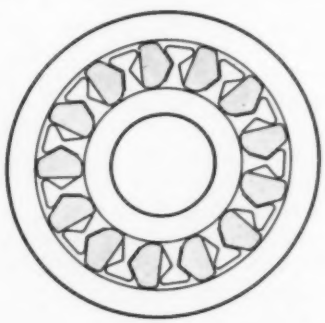



**Spherical bearings with carbon-filled Teflon lining . . .**
show better wear and shock-absorption characteristics than bearings with woven Teflon lining. Developed by the Heim Company, Fairfield, Conn, for their Unibal spherical bearings and rod ends, the new linings can take severe, repeated shock. Woven Teflon sometimes becomes self-crippling under such conditions because its fibers cut each other—but it has higher static load capacity and can take high speeds better. Teflon, in general, outperforms most metallic bearings (see ASLE report *PE*—May 15 '61, p 98).

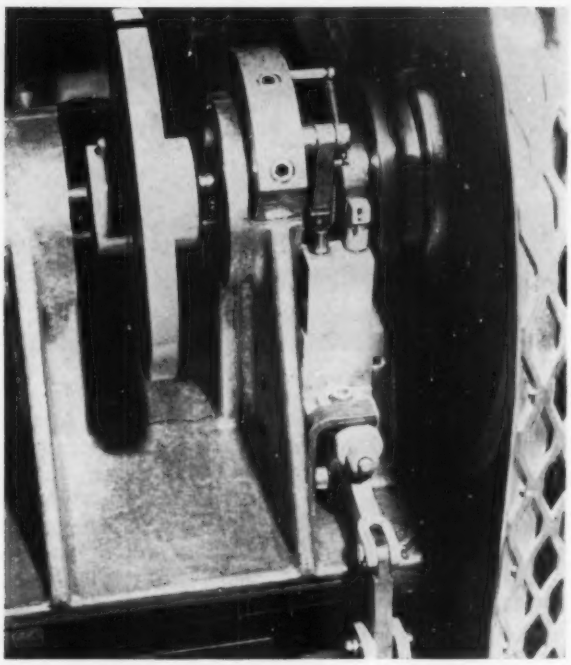
**Self-locking bearing nut . . .**
has nylon pellet imbedded in the threads for preloading and retaining a bearing on a shaft. Usual solution is to employ an SAE bearing retaining nut in combination with a tab washer. This requires a milled keyway in shaft. Also, preload cannot be finely adjusted. The new self-locking nut by Nylok Corp, Paramus, NJ, avoids need for tab washer or keyway and holds precisely the preload desired.

**Packaged, throw-away right-angle gear sets . . .**
will soon hit the market. Housed in aluminum extrusions, and lubricated and sealed for life, gear sets with Spiroid, Planoid or Helicon systems will be offered by Illinois Tool Works, Chicago, as low-cost reduction units. Ratios from 3:1 (to sell under $1 per unit in quantity) and up, using single, double and triple reduction arrangements. When noise indicates wear, the unit can be thrown away and replaced by a new right-angle gear set with little maintenance cost.

**Sprag clutch has leaf springs . . .**
for individual and more disciplined control of load-carrying sprags. Applied to a new line of miniature one-way clutches by Formsprag Co, Warren, Mich, the design replaces the familiar configurations using coil springs between groups of three sprags each.

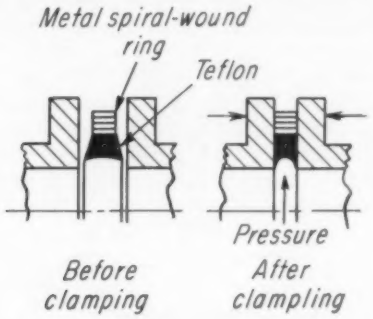


**Brake system for single-revolution clutch . . .**
has built-in dashpot and spring to absorb impact energy of rotating masses at the end of each intermittent rotation. Clutch is always engaged, but output rotation is prevented by trip cam. Energization of solenoid pulls lever away from cam, permitting rotation. After full revolution, the backstop latch strikes trip lever, which drives the plunger into an oil chamber. The chamber is connected by orifice to another chamber. Flow is restricted, and impact energy absorbed. The spring also ab-



sorbs shock, but its main purpose is to return the plunger. Device, by Hilliard Corp, Elmira, NY, is still in development stage but should be available soon.

**Teflon oil seal with trapezoidal configuration . . .**
changes shape when clamped to seal high-pressures. This latest innovation by Garlock Inc, Palmyra, NY, employs

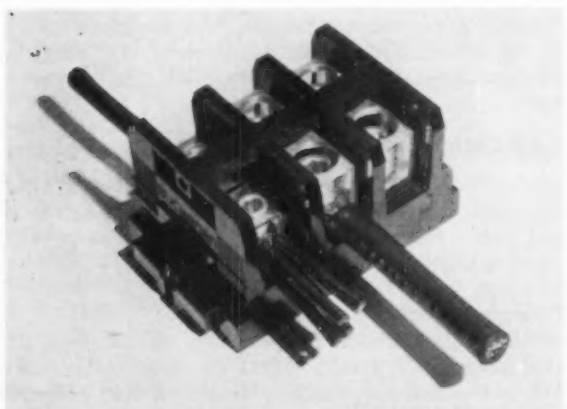



a spiral-wound outer ring and is recommended for hydraulic-pneumatic equipment operating at pressures over 10,000 psi. The seals can take corrosive oils at temperatures to 500 F.

**Constant-force coil springs and spring motors . . .**
are getting a bigger play. Associated Spring Corp, Bristol, Conn, is now entering this field with their Lev'l-Torq' (a spring motor) and Tru-Trac (a prestressed coiled strip). Hunter Spring Co, Lansdale, Penna, is offering $10 packages of stock Neg'ator springs for research and development projects. —Nicholas Chironis

## ELECTRICAL COMPONENTS

**Snap-together terminal blocks . . .**
made by Buchanan Electrical Products, Hillside, NJ, can handle 230-amp currents with conventional insulated conductors, and over 300 amp when conductors have hi-

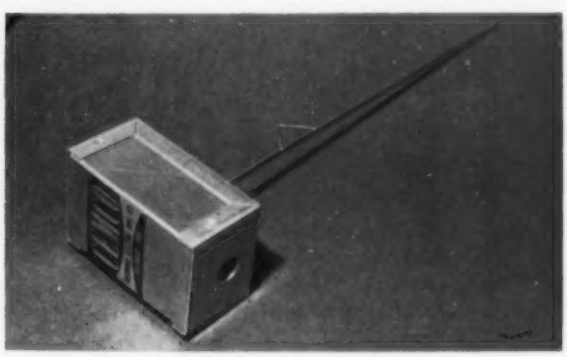


temp insulation. This new version augments Buchanan's older miniature line, and will mount in the same metal channel, using some of the same clamping hardware used previously.

**Snap-in panel mounting . . .**
for a prototype Microswitch by Minneapolis-Honeywell, Freeport, Ill, features all-nylon construction of housing and external holding fingers. Now being used for a refrigerator light-switch, it carries 10 amp 115 v ac, has $\frac{3}{8}$ in. overtravel of the pushbutton after actuation.

**Control for magnetic coupling . . .**
developed by Louis Allis Co, Milwaukee, Wis, eliminates electron tubes. Solid-state elements such as silicon controlled rectifier transistors and diodes energize and control the field of heavy-duty couplings (750-hp version at show). Interesting feature is a transistorized triggering circuit for the SCR's, replacing the conventional magnetic-amplifier triggers.

**Rod-and-tube thermostat . . .**
about 1 ft long and only $\frac{1}{8}$ in. dia, is under development by CEMCO (Columbus Electric Manufacturing Co, Co-

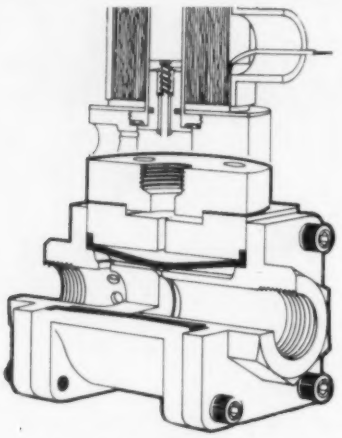


lumbus, Ohio). Prototype (photo) has $\frac{1}{16}$-in. Nilvar rod inside stainless steel tube, with differential movement of about 0.009 in./100 F. Rating of snap-action switch: 220 v ac, 1 hp. —Franklyn D Yeaple

continued, next page

## FLUID POWER COMPONENTS

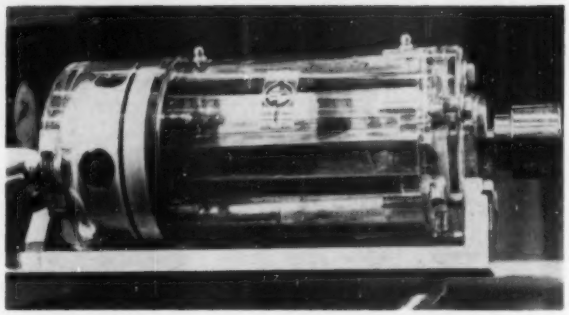
**Squeeze-type valve . . .**
is a novel solenoid-operated design exhibited by Airmatic Valve Inc, Cleveland, Ohio, for the first time at this show. Purpose of construction is to keep flow path (flexible tube)



separate from actuating mechanism (pilot valve); corrosive fluids can then be handled. Air or hydraulic pressure from pilot valve collapses tubing over porting holes to close main valve.

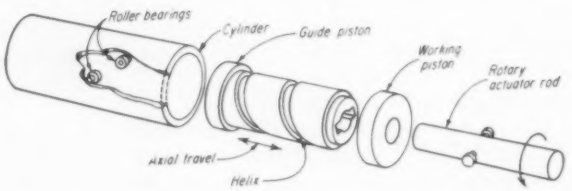
**Variable-displacement piston pumps . . .**
of two new in-line designs were introduced at the show by two manufacturers: Vickers Inc, Detroit, Mich, and Weatherhead, Ft Wayne, Ind. Vickers' pump has a swashplate to drive the pistons; Weatherhead's has a wobbleplate. This is the first time either manufacturer has offered an in-line pump, although Vickers has made an angle-type pump for a long time.

**Air motor . . .**
with radially moving rectangular pistons (resembling vanes in a vane pump) was introduced in prototype form (photo)



by Humphrey Products, Kalamazoo, Mich. Rotor has cam-shape cross-section and is driven by the pistons; a series of air valves maintains proper sequence. Speed can be varied from zero to 5000 rpm by increasing air pressure and flow, and torque is high even at low speeds. A 3-hp motor will weigh about 17 lb, and air consumption is claimed less than for conventional air motors.

**Rotary hydraulic-actuator . . .**
disclosed at show (not exhibited because it's still in development) has an external helix on piston instead of the conventional internal helix. Made by Carter Controls, Lansing, Ill, the design promises greater torque, and can




be made more easily (no internal helix to broach) to suit special requirements. Exploded sketch is artist's conception, and shows main elements. —William B Wallace

## METALS AND CERAMICS

**Beryllium-copper alloy . . .**
that is heat-treated at the mill, yet is easier forming than conventional alloys, has been developed by Brush Beryllium, Cleveland, Ohio. Brush reports that its alloy 190, containing about 1.85% Be, has equivalent or better strength than former alloys, containing less Be, that have to be heat treated after forming to give full properties.

**New high-strength steel . . .**
is a 25% nickel alloy developed by International Nickel Co and available from several steel companies as well as Inco. The steel has a tensile strength of 250,000 to 285,000 psi, yield strength of 240,000 to 275,000 psi, elongation of 12 to 10% and reduction in area of 55 to 45%.

**Faster anodizing process . . .**
reported by Alcoa uses higher current densities, cuts treating time from 1 hr to 20 min for standard finishes; performance is said to be unimpaired. Aluminum Extrusions Inc, Charlotte, Mich, indicates increasing interest in combination finishes such as: sanded finish with bright anodizing, black paint with gold anodizing for antique effects, and paints that simulate etched aluminum to go with bright anodizing.

**Perforated metals . . .**
with hole diameters less than the metal thickness are now available from National-Standard Co, Niles, Mich. N-S uses a new German punching technique that perforates at an angle to the plane of the sheet, and leaves triangular holes. Equivalent diameter of such holes in 26 ga (0.0187 in.) stainless can be as low as 0.002 in. Hein-Lehman of Dusseldorf developed the "Conidure" method.

**A cermet composed of tungsten carbide and tantalum . . .**
will resist erosion of high-velocity, high-temperature gases. Called a "carbon exchange alloy" by its developer, Kennametal Inc, Latrobe, Pa, the material, when exposed to temperatures over 5000 F, releases carbon from the tungsten carbide. This carbon then forms tantalum carbide which provides added high-temperature resistance.

Aerojet-General is said to be checking the material under rocket conditions over 6000 F. Parts are formed by conventional powder-metal techniques.

**Sheet metal continuously clad with powdered silver . . .**
alloy may soon be available from Metals and Controls Div of Texas Instruments, Attleboro, Mass. Graphite or $MoS_2$ is added to the silver layer, according to M & C, to prevent "welding" when the strip is used as an electrical contact material. Most common base metals can be used as the underlayer and the clad strip can be punched and stamped, though bending and drawing limits have not yet been determined.

**Leaktight honeycomb core material . . .**
for sandwich panels can be produced in stainless or copper by a "diffusion welding" technique devised by Hexcel Products Inc, Berkeley, Calif. By applying pressure through mandrels at the nodal point while the material is hot, continuous "single crystal" welds are produced that preclude burn-through. In addition to leak-tightness, method avoids buckled walls. Core strength in tension is 30% higher than other welded honeycomb, according to Hexcel. Stainless sheet as thin as 0.0005 in. can be made into honeycomb in this manner. The process has also been applied to PVC plastic, resulting in a resilient material for possible cushion applications. **—Ford Park**

## PLASTICS

**Filament-wound reinforced-plastic structures . . .**
are more in evidence as major vulcanized-fiber manufacturers enter the field for commercial markets. Newest entries: Spaulding Fibre, National Vulcanized Fibre and Taylor Fibre. Fuse-bodies for high-voltage power lines were made by strengthening vulcanized fibre tube with continuous wrapping of impregnated glass cloth. Now, much higher pressure ratings and lower costs are obtained with a filament-wound epoxy-glass wrapping.

Wire can replace glass fibers as the filament. American Steel and Wire Div of US Steel reports that pressures up to 600,000 psi can be contained in air rocket fuel tank, ellipsoidal in shape, wound using 0.0025 in. dia wire.

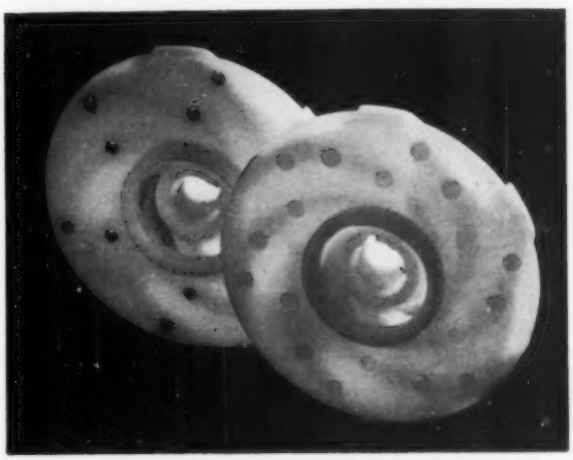
**Woven reinforcement is a growing competitor . . .**
for wound reinforcement. Here, glass roving is woven over a mandrel and coated with resin, thus giving much higher interior shear strength via interlocking strands. Polygon Plastic Co, Walkerton, Ind, is developing the technique for pressure vessels, with closures woven in place and mandrel melted out. Structural shapes can be made over any convex-section mandrel, with resulting tube cut into angles and channels as desired. Composite parts are made by weaving over a fiberglass (or metal) mandrel produced by drawing impregnated roving through a shaped hole. Max tube size 6 in. so far; wrapping the covered mandrel with Mylar tape allows thin walls and smooth surfaces.

Tubes extruded from thermoplastics like PVC, nylon, and fluorocarbon resins can be reinforced in a similar process developed by US Stoneware Corp, Akron. Here, roving is continuously braided at the extrusion head and caught between an inner and outer tube. Technique permits a variety of pressure ratings (depending on braid configuration and tube dimensions), as well as combining two different plastics in the same tube.

**Printed circuits made continuously . . .**
may become a reality as a result of a new epoxy-glass laminating technique. Developed by Swedlow Inc, Youngstown, Ohio, the process continuously impregnates glass cloth with epoxy resin and laminates the resulting sheet between layers of polyester film. Resulting sandwich is post-formable. Work is proceeding on this addition of copper cladding on one or both sides. New laminate will be marketed by Spaulding Fibre, Tonawanda, NY.

**Extra-hard castable urethane rubber . . .**
is made by Disogrin Industries, Mt Vernon, NY. The new rubber has a durometer hardness of 65D, compared to 90-95A for present grades. Tensile strength is 4000 psi, ultimate elongation 250%, elongation set 36%. Load for 5% tensile elongation is 2000 psi, compared to 540 psi for 90A stock. Disogrin reports that new grade in bearing and thrust washer applications wears in to a coefficient of friction very near that of Teflon. Abrasion resistance is less than for 90A durometer material.

**Cold-heading replaces riveting . . .**
in this pump impeller made from DuPont's Delrin acetal resin. Impeller at left was molded in two halves, rivets inserted and deformed. Right-hand impeller has prongs molded in place on one half which extend through holes molded in the mating part. A load is applied, via a

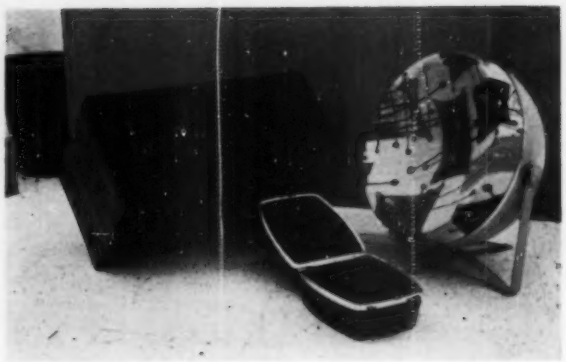


multiple-headed tool in a punch press, in excess of the compressive yield stress of Delrin (17,000 psi at 73 F) and the protruding prongs headed to shape. Punch press operates at about 20 in./min and assembles 200 impellers per hr. Jig is spring loaded to eliminate impact. New impeller is now standard in Flint & Walling Manufacturing Co's submersible pump.

**Electrically conductive fluorocarbon resin . . .**
is made by adding conductive, nonmetallic filler to its Fluorosint resin. Polymer Corp, Reading, Pa. has

developed a material with a resistivity that can be varied from 2.5 to 1 million ohm-cm. Mechanical properties, at any resistivity level, can be varied between those of the flexible Teflon and the hard, sintered fluorocarbon. Applications: brushes, non-sparking conductive bushings.

**Synthetic fiber cloth is molded to shape . . .**
at right, new portable loudspeaker has grille cloth thermoformed to retain convex shape. For more intricate and sharper contours, as on speaker at left, matched die molding is needed. All textile parts on products shown here, including liner for instrument case (center), are made from Dynel, acrylonitrile-vinyl chloride copolymer from Union Carbide Corp, NY. **–Ford Park**



## DESIGN IDEAS

**Fiber optics may be off-the-shelf . . .**
components according to American Optical Co, Southbridge, Mass. Fiber bundles are available in lab quantities for special applications. Both coherent bundles (in which fibers maintain same position in the array at both ends) and incoherent bundles (for use, chiefly as a flexible "light pipe") are being produced. Many interesting applications are possible: With tapered fibers, an image can be magnified or reduced. And a small bundle of incoherent fibers makes an excellent "cold" light source. Even a single fiber gives a pinpoint of light of unusual brilliance.

Price is still high–about $75 for a 50-ft incoherent bundle of 1-in. dia and about $1500 for a coherent bundle of the same size.

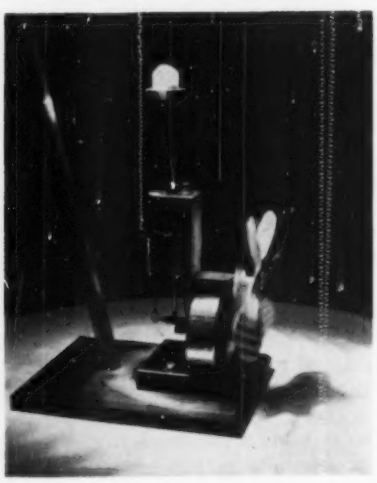
**Drafting board with simpler height and tilt adjustments . . .**
is the goal. Hamilton Mfg Co, Two Rivers, Wis, has redesigned its Auto-Shift drafting table in accordance with stop-motion photographic studies of draftsmen at work on all kinds of tables. The new table has a torsion-bar counterbalance adjustable to compensate for weight of drafting machine, lamp and other accessories. Hinge is a multiple-leaf unit acting as lock when leaves are compressed. Board is linoleum-covered honeycomb. Sliding reference surface pulls out from under drawing board into draftsman's lap. It can also slide in the opposite direction to provide a reference surface for next man in drafting row.

**Tilt pedal does not move with height changes . . .**
on the new Stacor-Matic (by Stacor Equipment Co, Newark, NJ). New board gives draftsman more knee room and full 15 in. up and down adjustment. Drawers and pedestal have been restyled to give table a clean modern look.

**Manual impact wrench . . .**
called a Swench (part sledge, part wrench) is manufactured by Marquette Div of Curtiss Wright. Like its powered counterpart, it applies controlled torsional impacts to loosen stubborn nuts or tighten them to a preselected tension. Looking like an oversize ratchet wrench, the Swench stores energy in a heavy coil spring in the handle and releases it to the business end when the handle is pulled through an arc of 30°. It is available in six sizes with handle lengths from 9 in. to 60 in. Torque multiplication for all sizes is on the order of 15 to 1, and magnitude of impact is adjustable except on smallest model. Prices vary from $40 for the 9-in. model to $795 for the 60-in.

**Micrometer with digital readout . . .**
has a miniature drum counter in the back of the anvil. White on black figures read in thousandths and backlash in the counter gear train is undetectable. The "D. R. Micrometer" is available from Kromedge Distributing Co, Brooklyn, NY, comes in two sizes: 0 to 1 in., $35; 1 to 2 in., $38.

**Stirling engine . . .**
runs at about 100 rpm on heat from a sun lamp. It was built by engineers at Battelle Memorial Inst, Cleveland, Ohio, in a program aimed at proving out the Stirling's practicality, simplicity, quietness and reliability. Major



part of the study is being done on an analog computer so that engineers can vary 16 engine parameters to find optimum combination for any particular set of design conditions. (See this and other novel power sources described in detail in the June 26 issue of PRODUCT ENGINEERING.) **–Charles J Lynch**

# Solve Multi-Point Temperature Control Problems...

## *at ⅔ cost of competitive systems*

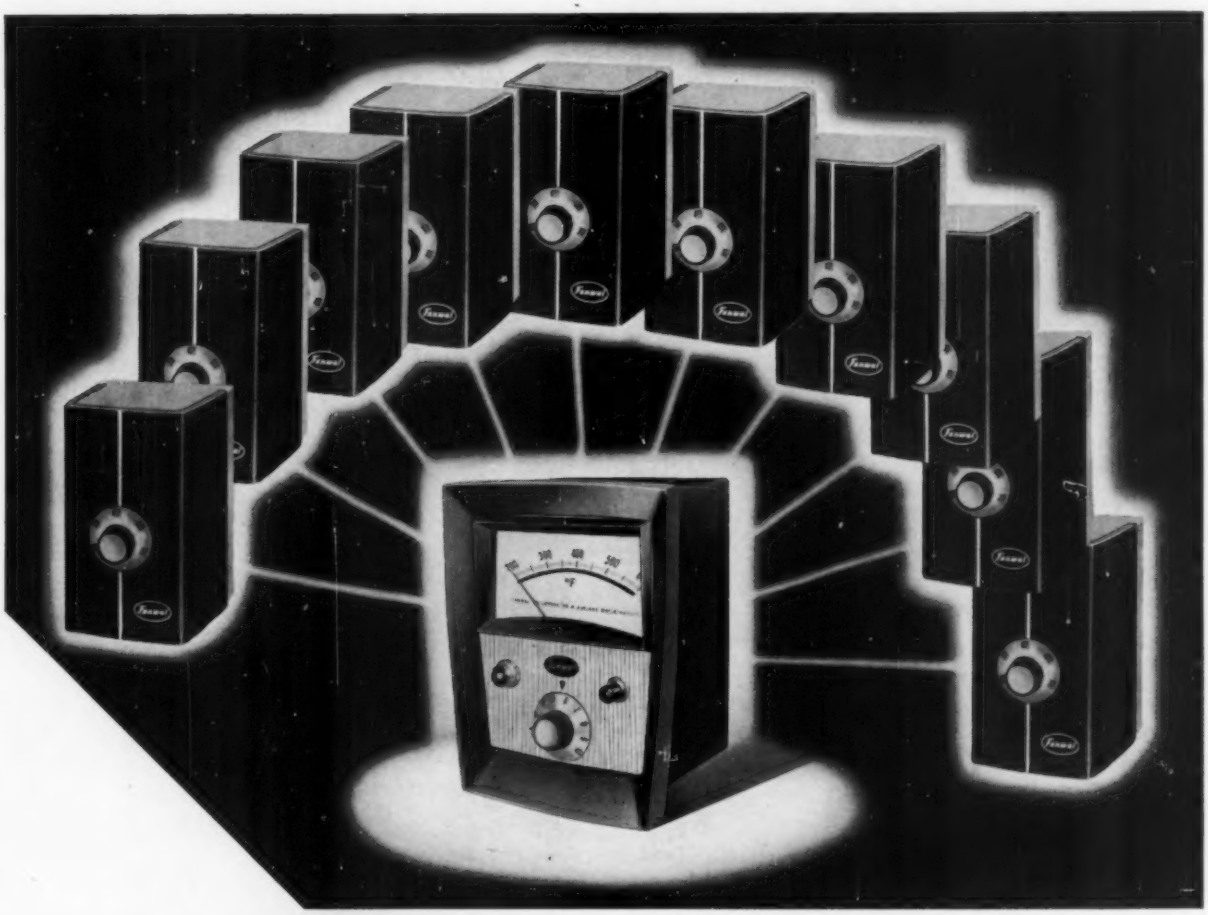
**You get them all — wide ranging versatility . . . maximum sensitivity . . . easy installation and servicing! These features *combine* in a Fenwal 536-580 multi-point monitoring system to give you precise, transistorized temperature control and indication. And *you choose the features you need to suit your own requirements!***

***Examine these cost saving advantages:*** **Indication and control circuits are separate . . . the 536-580 system eliminates the need for separate indication and control at each point. You can build a control system concurrent with your needs — start with 2 points and build up to 10 points without paying a premium at the outset. The complete control system is built from *standard* catalog parts, thereby eliminating the need to buy costly "specials" for servicing at a later date.**

**Individual points can have either proportioning or ON/OFF control modes. The system permits "flick of switch" indication of from 2 to 10 temperatures. Individual set points can be adjusted from a central control panel or through a separate potentiometer remotely located. You select your own number of points and you *pay only for the options you use.***

**Choose from five standard temperature ranges — from −50 to 600°F . . . expanded scales permit fine temperature adjustments and improved readability, and *the entire system gives you sensitivity to within 0.1°F.***

**Both instruments are smartly styled to perfectly complement modern industrial machines and interiors. A Fenwal engineer will be glad to supply information on this system, or any other temperature control in Fenwal's broad line. Write Fenwal Incorporated, 26 Pleasant Street, Ashland, Mass.**



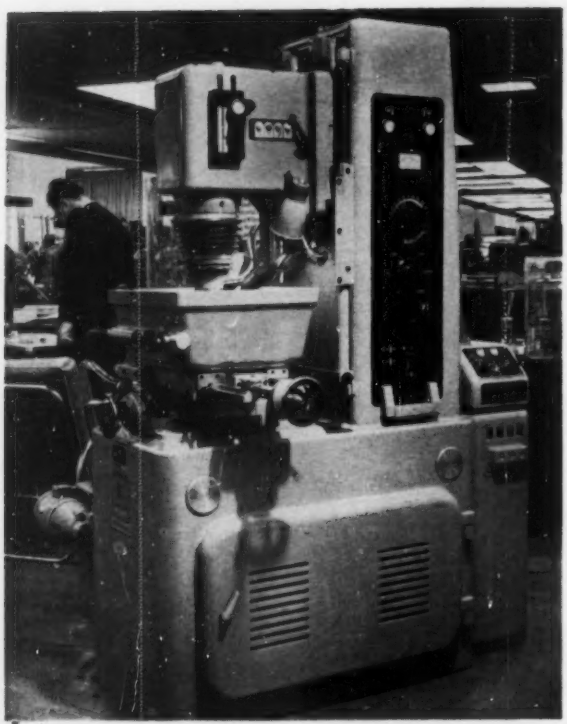
*Another example of how* **Fenwal** CONTROLS TEMPERATURE . . . PRECISELY

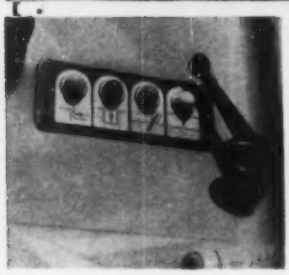
# Better-organized Design Helps European Machines at Tool Show

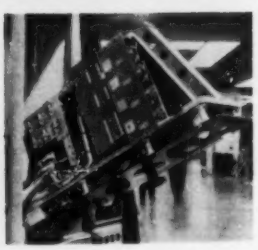
**GERALD STAHL,** industrial designer; NYC; **JOHN KOLB,** associate editor

■ Although a number of American machine-tool builders were exhibitors at the May 22-26 Tool Show in New York's Coliseum, it was mainly some of the European exhibitors whose machines looked as though their engineers and designers had thought their designs through from start to finish. Notably, their control panels and the related elements were sensibly arranged, and had the most readable combination of numerical, graphic, symbolic and other means of identifying knobs, levers, dials and buttons. Curiously enough, virtually all the manufacturers exhibiting—European and US alike—seem to be missing opportunities to use color for quick identification of controls and their functions.

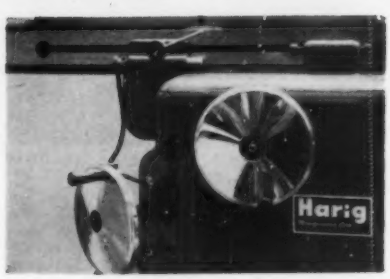
Over-all, only a handful of the machines exhibited reflect the highly complex nature of the modern production machine. Most of them look like the fifth or sixth-generation models of original designs dating back to the early thirties. ■



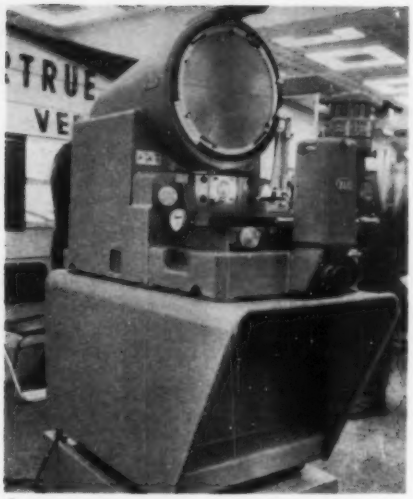




**Automatic spark-erosion machine** designed and built in Switzerland by Ateliers des Charmilles S A has a well-organized control panel that uses standard European control symbols representing direction, surface finish, speed, machine systems for operators who speak different languages. Color would have further strengthened relationship of knobs and levers to their control functions. Control panel also serves as cover of tilt-down chassis containing modular plug-in circuitry.




**Surface grinder** (right) by Harig Mfg Corp, Chicago, shows how good US design can be when it is well-planned and carried out. All major machine elements have been kept as minimum and simple as their function would permit—no metal has been wasted on meaningless "streamlining" ridges and curlicues. One model was equipped with closed-construction hand wheels that look as though they probably provide less chance for things to get caught on.



A

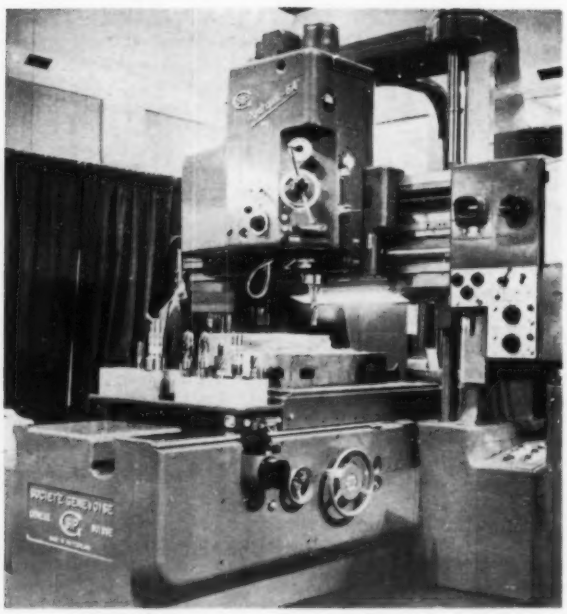
B

C

**A Contour projector** for parts inspection exhibits a compactness distinguished by functional placement of clearly identified controls—placed well inboard of instrument perimeter together with all moving elements. Unlike much highly technological equipment, this projector, made by Optical Gaging Products Inc, Rochester, N Y, doesn't look forbidding; it looks easy to use. Unusual base gives full front-to-back support and stability in minimum floor space.

**B Where two-dimensional measurements** are required, coordinate-measuring machine replaces slow and tedious surface-plate and height-gage inspection procedures. Control head, being inspected by author Gerald Stahl, consists of many complex components, but here it has been integrated into a single, rectangular cube, strongly projected from console panel. Rational organization of readouts, controls, and housing itself into a simplified whole, helps emphasize advanced technology behind the development and design of this instrument. If it looked anything other than up-to-date and functional, it would probably not appear to be up to its own technology. English-designed and built by Ferranti.

**C Vibration signal analyzer** and operation monitor are based on a modular design concept that permits user to interchange plug-in circuitry components according to the particular machine-analysis task to which it is to be applied. Control and display panel is organized vertically according to the type of measurement. Industrial design done by Raydata Corp's engineer-president George Foster and the engineering staff, as part of the over-all engineering function.



**Jig boring and milling machine** (above) by Societe Genevoise d'Instruments de Physique of Switzerland, and production boring and milling machine (right) by Schwartzkopf Gmbh of West Germany, illustrate two different ways to handle problems of designing extra-large, highly automatic machinery having several massive elements and a large number of controls. The Swiss machine separates control and adjusting knobs, levers, dials and readouts into a number of groups, located to function or machine element. The German machine groups all controls into a single area, using color (the only complete job at the show) to distinguish between the groups functionally. Both machines use clean-lined housings of minimum bulk to minimize size and achieve over-all integrated look.

# Chace

THERMOSTATIC BIMETAL

ACTUATES ANOTHER PRECISION PRODUCT . . .

Westinghouse

TRI-SNAP THERMOSTAT

A PRODUCT OF
WESTINGHOUSE ELECTRIC CORPORATION
MANSFIELD, OHIO

You can be sure . . . if it's Westinghouse. Typical of the many great products described by this famous slogan are the safe, clean, efficient Westinghouse Electric Water Heaters. Westinghouse Water Heaters more than match the demands in today's homes for a constant supply of hot water. The secret of their maximum operating efficiency is the Direct Immersion Element—a unique heating element installed inside the tank. Completely immersed in the water, it heats silently and safely . . . no heat is lost.

A most important contribution to the efficient and economical operation of these fine water heaters is the Tri-Snap Thermostat, the automatic temperature control which accurately controls the heating element to keep the water at its pre-set temperature (from 120°F to 170°F).

The Tri-Snap Thermostat is actuated by a three-legged element of inherently snap-acting Chace Thermostatic Bimetal. Chace has long been recognized for the extreme dependability of its one product: precision Thermostatic Bimetal. In the field of Bimetal for snap-acting elements Chace is the unchallenged leader. The Chace Thermostatic Bimetal in this application can be expected to perform for years—exactly as specified through thousands of cycles to help prove that "You can be sure . . . if it's Westinghouse". Manufacturers the world over know their names are safe on the outside with Chace Thermostatic Bimetals on the inside of their products.

*Send Now For Our New "Information Booklet"!*

It contains many well illustrated pages of valuable design data and examples of successful applications of bimetal! More than 40 types of Chace Thermostatic Bimetal are available in coils, strips and completely fabricated elements of your design.

IT BENDS WITH THE HEAT

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Thermostatic Bimetal
1602 BEARD AVE., DETROIT 9, MICH.


## READER TO EDITOR

### Ancestor of New Bicycle Gear

*To the Editor:*

About 45 years ago I had a bicycle with a Corbin two-speed rear hub which, as far as I can remember, was almost identical to the one that received one of your Master Design Awards (May 22 issue, p 39). It shifted each time I stopped pedaling, alternating from high to low and back on successive coasting. At that time I lived on the outskirts of a small Michigan town a mile from school. There were two long hills which could be ridden up quite easily with the low gear. I rode the bicycle until I went away to college in 1923.

A year or so after I got the bicycle my curiosity made me take the transmission apart. I took it apart several times for oiling and cleaning and to show friends how it worked. I never had any trouble with it and considered it a well-constructed device.

—G H Wotring
*Morrison, Ill*

### More Cracks About Glass

*To the Editor:*

I have personally observed six tempered-glass failures, one in my own car. In each case the whole glass fractured into particles roughly $\frac{1}{4}$ x $\frac{3}{8}$ in. rectangular and very uniform; there were some rough edges but generally they were smooth.

Here is another argument for sandwich glass. Once while doing 60 mph, a half brick was thrown from the double wheels of an oncoming truck. The projectile's speed must have been about 110 mph, so it must have hit my windshield at about 170 mph. Both panes shattered directly in front of my face. I had time only to blink. Tempered glass would have allowed it to come through—or would it?

—A J Tricon
*Houston, Texas*

### Watch That Trademark!

*To the Editor:*

In your Mar 27 issue, p 12, we note an article entitled "City Mail Delivery to Be More Mobile." You mention that the Post Office Department has ordered 300 electric three-wheel "Mailsters." We wish to call to your attention that the word "Mailster" is a registered trademark held by Cushman Motor Works Inc, a subsidiary of Outboard Marine Corporation.

—R D Von Seggern
*Assistant chief engineer, Vehicles*
*Cushman Motors*
*Lincoln, Neb*

### Supports Change To Metric System

*To the Editor:*

I am certain you will want to call to the attention of your readers the desirability in their support of bill HR269, which was introduced by Congressman James Roosevelt in the House of Representatives. This bill authorizes a study into the practicability and desirability of the United States adopting the metric system of weights and measures.

As you know, a large majority of all scientists and engineers have been in support of adopting the metric system of weights and measures for many years.

—R M Mehl
McClintock Manufacturing Co
Whittier, Calif

• Another straw in the wind was datelined Washington on April 8: "The Army plans to change from the yard to the meter in making linear measurements for its weapons and related equipment to direct and coordinate fire . . . by Jan 1, 1966." The move is designed "to simplify firing procedures" and to further standardization within NATO. An exception will be made for equipment in the Continental Air Defense System. —EJT

### It's Not a JATO

*To the Editor:*

Your fine article on the progress of Project Mercury in the May 1 issue, p 15, was of great interest to GCR personnel since we have had a subcontract from McDonnell to develop and build the escape rocket for the space capsule.

We noticed, however, that the escape rocket was described as "a system of JATO bottles." The GCR escape rocket is a single solid propellant rocket having three canted nozzles. The unusual placement of the nozzles sometimes makes it appear that there is more than one motor.

—Janet E McKim
Public relations representative
Grand Central Rocket Co
Redlands, Calif

## COMING EVENTS

### JUNE

**11-15** . . . . American Society of Mechanical Engineers, Summer Annual Meeting, Statler Hilton Hotel, Los Angeles

**18-23** . . . . American Institute of Electrical Engineers, Spring General Meeting, Cornell Univ, Ithaca, NY

**25-30** . . . . American Society for Testing Materials, 64th Annual Meeting Chalafonte-Haddon Hall, Atlantic City, NJ

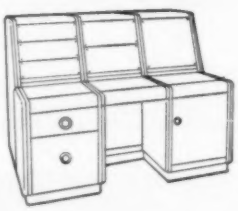
**26-30** . . . . American Institute of Electrical Engineers Conference on Concepts and Design in Aerospace Electricity, Benjamin Franklin Hotel, Philadelphia

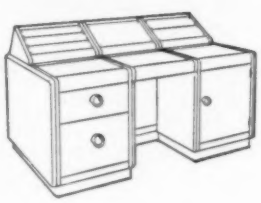
**26-28** . . . . American Society of Heating, Refrigerating and Air Conditioning Engineers, Annual Meeting, Denver-Hilton Hotel, Denver

**28-30** . . . . Institute of Radio Engineers, ASME, AIEE, ISA, AIChE, 2nd Joint Automatic Control Conference, University of Colorado, Boulder

For a listing of addresses of societies and associations send 25¢ to Product Engineering Reader Service Dept, 330 W 42nd St, NY 36. Ask for brochure R 32.

# EMCOR STANDARD CABINETS





- Cut enclosure design time. Select your packaging needs from a complete line of standard and heavy duty EMCOR Cabinets.
- EMCOR MODULAR ENCLOSURE SYSTEM Cabinetry provides for thousands of control center combinations.
- Choose from hundreds of EMCOR Cabinet widths, depths and heights offering an exclusive combination of engineered features.
- Engineered simplicity of basic frames and components affords quickest and easiest erection of control center assembly.
- EMCOR Cabinetry Engineers backed by the research and development "know-how" of the Roy C. Ingersoll Research Center set the pace for the packaging needs of electronics, instrumentation and electro-mechanical engineers from coast to coast.
- Rugged frame construction surpasses all standard requirements for increased load carrying capacities.
- Compatible cabinet design assures simplified and economical expansion at any time.
- EMCOR Cabinet manufacturing meets rigid quality-controlled craftsmanship standards.
- Nationwide organization of EMCOR Sales-Engineering Representatives assist in planning stages and assure customer satisfaction beyond the sale.

Condensed Version of Catalog 106 Available Upon Request.

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Division of Borg-Warner Corporation
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QUALITY EMCOR PRODUCTS
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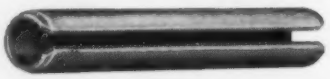
BORG-WARNER

# Send ESNA

# YOUR ROLLPIN® NEW-

## *Valuable prizes for*

**WHERE CAN YOU USE THIS SIMPLE FASTENER?**



ROLLPIN is the slotted tubular spring pin with chamfered ends that is cutting production and maintenance costs in every class of industry. Drives easily into standard holes, compressing as driven. Spring action locks it in place—regardless of impact loading, stress reversals or severe vibration. ROLLPIN is readily removable and can be re-used in the same hole. Made in carbon steel, corrosion resistant steel and beryllium copper.

ROLLPINS seem to find new cost-saving uses almost daily. The 9 examples pictured below—where ROLLPINS are shown replacing 9 types of fasteners—only begin to indicate ROLLPIN's wide areas of usefulness. We know of dozens of variations of the nine uses shown. You must certainly know some, too. So tell us yours—it could be a winner!

*P.S.* If you aren't now using ROLLPINS these 9 examples may give you some useful ideas. So why not write for a generous sample assortment of ROLLPINS and complete information. Dept. R61-697.

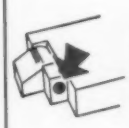
### ROLLPIN REPLACES 9 DIFFERENT FASTENERS!

**REPLACING A GROOVED PIN . . .** here Rollpin serves as a stop pin. Its light weight and shear strength function perfectly . . . cuts assembly costs.

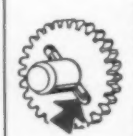
**REPLACING A SET SCREW . . .** a short length Rollpin is self-retained in the handle of an automobile brake. Is readily driven into over-drilled hole in shaft for easy removal.

**REPLACING A HEADED PIN . . .** in this hinge pin application, constant spring tension holds Rollpin firmly in place . . . eliminates loosening of hinge due to wear.

**REPLACING A RIVET SHAFT . . .** Rollpin serves as an axle for the sparkwheel of a cigarette lighter. No riveting or threading necessary. Faster assembly.



**REPLACING A CLEVIS PIN . . .** here Rollpin holds firmly in clevis, permits free action of moving member.



**REPLACING A HUB ON A GEAR . . .** Rollpin, self-retained in shaft, is simply snapped into molded slot to position sintered gear. Rollpin's shear strength is particularly valuable here.

**REPLACING A COTTER PIN . . .** Rollpin assembly time is shorter, service life ten times longer. Vibration-proof flush fit. Easily removable.

**REPLACING TAPER PINS . . .** Rollpin eliminates cost of taper pin reamers and the entire reaming operation. Rollpin costs less than a taper pin and installation is cheaper.

**REPLACING A BOLT AND NUT . . .** Rollpins act as fasteners and pivots . . . may also be used with a free fit in outer or inner members depending upon product design requirements.

# APPLICATION IDEA

## *the winners!*

**Portable transistor radios for the 25 best new ideas!**

Win one of these Sylvania portable transistor sets complete with deluxe carrying case.

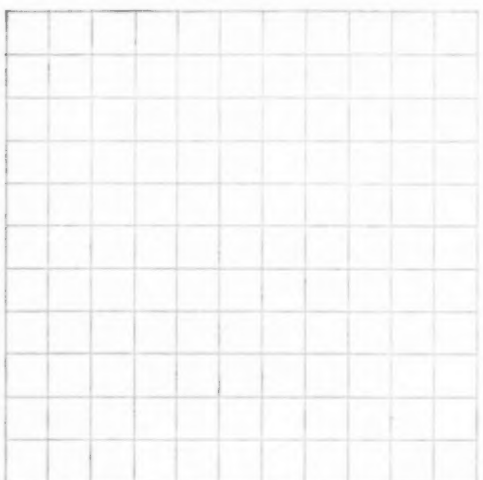
Your ROLLPIN application could be a winner!

Because design and production engineers are constantly on the lookout for new solutions to problems—and are constantly finding them—we've decided to go to you as the best source of new ROLLPIN application ideas.

You may have hit on a ROLLPIN application that has been extremely helpful to you—one that might spark ideas for others, too. So why not tell us about it and maybe win an extremely useful prize to boot?

Just do this. On the attached official entry form rough out a little sketch of your application on the graph section provided. Alongside it, write a brief description of the application and its advantages for you. Try to keep it to 25 words or so—to make matters a little easier for our judges. Judges will be our own ROLLPIN design staff. They will select the 25 entries that they feel open up the widest areas for new ROLLPIN applications, or that are most ingenious and novel.

## *Official Entry Form*



Use this form to make a sketch of your ROLLPIN application idea and for a brief 25 or 30 word description. If you wish you may attach a print, but it is necessary to complete this form to enter. Entries cannot be returned, and the judges' decisions will be final. Entries must be postmarked no later than July 15th, 1961 to be eligible. Winners will be notified.

_____

_____

_____

_____

Name_____

Company_____

Title_____

Address_____

All entries become the property of ESNA and may be used at any time by ESNA without compensation to the contestant. This offer is not made in any state in which it would be illegal, and is not open to employees, representatives or agents of ESNA.

ESNA

**ELASTIC STOP NUT CORPORATION OF AMERICA**

P.O. Box 1516, Union, New Jersey.

ROLLPIN

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PRECISION-FORMED
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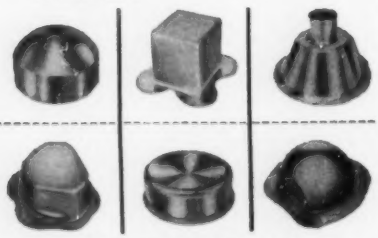
COMPONENTS

**Hydroforming, Deep Drawing and Spinning**

You can depend on KAUPP for complete service from design to delivery on precision-made metal parts and sub-assemblies. Ultra modern metal working facilities, plus wide experience on military and commercial requirements are available to solve your problems. Send drawings for quotations or phone for new illustrated bulletins!



Closest tolerances adhered to in all metals, including MU METAL, BRASS, INCONEL, ALUMINUM, COPPER, CARBON STEEL, STAINLESS STEEL, NICKEL, MAGNESIUM, TITANIUM, SILVER, SPECIAL ALLOYS, HAYNES STELLITE.

**C. B. KAUPP & SONS**

Newark Way, Maplewood, N. J.—POplar 1-4000

METAL CRAFTSMEN
SINCE 1924

# WHY DON'T THEY R&D..?

. . . some commercial application for these two laboratory curiosities.

1. **The electret,** a device that bears the same relation to electric fields as magnets do to magnetic fields. It is simple, consisting primarily of a composition of waxes which are melted and then allowed to cool in an electric field of several thousand volts. This polarizes the wax and leaves a residual charge of 200 volts or more, which the wax will retain indefinitely. A typical electret contains waxes mixed in these proportions: 45% carnauba wax, 45% water-white rosin and 10% beeswax.

Because of a mechanism that is not yet understood, the electret must be allowed to age for several months after being charged. When first charged, the polarity is just what theory predicts: the negative face is the one that was in contact with the positive electrode during cooling, and vice versa. But this charge begins to diminish, and in about one week will have fallen to zero. It then begins to build up in the opposite direction and eventually reaches a value several times its original charge. The aging process may take as long as three months.

Though the phenomenon has been known for several hundred years, and despite the electret's simplicity and low cost, it has yet to find steady employment in any electrical or electronic apparatus. It has been incorporated in electrostatic generators and was used for a time for electrostatic focusing of television picture tubes. It has also been tried in microphones in which relative motion between the electret and a metal disk generated an electronic signal. But mostly it has been ignored and still waits for an ingenious engineer to develop its full commercial potential.

2. **Dielectrophoresis,** the phenomena that moves neutrally charged particles in nonuniform electric fields. Dielectrophoretic forces are weak compared to those that the same field produces on charged particle (electrophoretic forces), but are sufficient to pump water against a 4-foot head at the rate of a gallon a minute with an efficiency of about 25%. The dielectrophoretic effect works this way: In an electric field, a neutrally charged particle (a molecule of water, for example) becomes polarized so that the side facing the positive electrode develops a negative charge and vice versa. In a uniform field, the charges cancel and there is no net force on the particle. But in a nonuniform field, such as that between a wire and a surrounding tube or between a wire point and a circular plate, the particles are drawn to the area of highest field intensity. (Changing the polarization of the field does not change the direction of the force on the particle. For this reason, an ac field works as well as a dc field.)

The dielectrophoretic force depends on the strength of the field, the size and dielectric constant of the particle, and the electrical conductivity of the surrounding media. In extremely strong fields, particles drawn to the electrode become charged and are then expelled violently by electrophoretic action. This effect can be used to stir or pump liquids.

In the laboratory, the dielectrophoretic effect has been used to separate powders of different dielectric constant. In the same way, it can also precipitate particles suspended in a liquid. Small pumps that operate on the combined dielectrophoretic-electrophoretic effect have been built in laboratories to throw water around in a truly spectacular fashion. But the commercial possibilities of this laboratory curiosity remain essentially untapped.

**Have you a problem, based on known scientific principles, which seems to have an answer somewhere within the limits of present technology? To inspire inventors along worthwhile paths, PRODUCT ENGINEERING invites you to trade such problems with fellow readers who have a fresh viewpoint or more time to experiment. We pay $10 for each one accepted.**

if she takes pride
in her home—

give her a kitchen
of stainless steel

**McLOUTH STAINLESS STEEL**—the spotless metal for homes and home products.

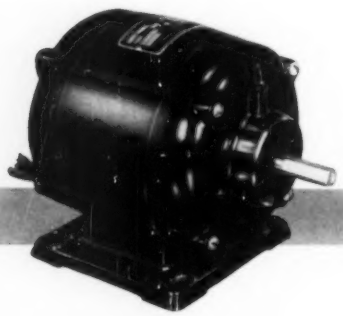
*McLouth Steel Corporation*
*Detroit 17, Michigan*

Bodine Motors Give You **ADE** (**A**fter **D**elivery **E**conomies)
Here's another example

# "BODINE MOTORS easily meet our high standards for quality"

says Mr. Joseph Konkel
Chief Mechanical Engineer
Anelex Corporation
Boston, Massachusetts

"The reputation and reliability of our Anelex Print Station is due entirely to our insistence upon quality . . . a specification easily met by Bodine, and a requirement we'll not sacrifice at any cost. We've always used Bodine Motors. Their efficiency, among other characteristics, is outstanding. And Bodine's wide range of standard motors lets us select the proper motor for a particular operation without need for costly special modifications."



Workhorse of the electronic data processing industry is the Anelex high speed Print Station which translates computer language into usable form. It has set the industry standard for reliability and has been designed into the systems of nineteen major manufacturers of commercial and scientific computers. In this Anelex model, two small Bodine capacitor motors drive paper feed and print roll mechanisms, a type KCI gearmotor operates the ribbon drive.

BODINE
fractional BODINE horsepower
MOTORS
*. . . the power behind the leading products*

Bodine motors actually cost less when you figure final-costs because: (1) Closely-held tolerances and uniformity of Bodine motors minimize installation cost. (2) Reject rates are low. (3) Bodine motors almost never require field servicing. (4) High, consistent performance of Bodine motors helps your product earn customer satisfaction and repeat sales. Want more details? . . . ask for Bulletin S-2A.

Bodine Electric Co., 2510 West Bradley Place, Chicago 18, Illinois

Gasket engineering

# BOLT LENGTH VS. TORQUE RETENTION

**Bolt length and bolt torque are important factors in maintaining flange loads on gasketed joints. New engineering studies show the extent of these effects to be greater than anticipated.**

E. M. SMOLEY
Research Physicist
Armstrong Research and Development Center

Retention of bolt torque on gasketed joints is a function of several factors. Two important ones concern the bolt itself: its length and the amount of torque initially applied to it when the joint is tightened.

Recent tests were conducted at the Armstrong Research and Development Center to study (1) the relation of bolt length to torque retention; and (2) how torque retention is affected by variations in the amount of torque originally applied to the bolts.

In these tests, separate steel flanges were prepared to accommodate three different bolt lengths—½", 1", and 1½". (See Figure 1 for definition of bolt length.)

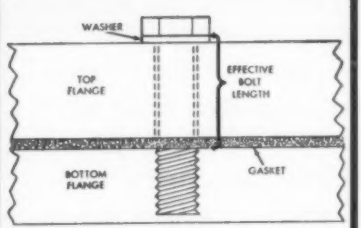



Figure 1. Here bolt length is defined as the distance from the underside of the bolt head to the face of the opposing flange—including the washer and the compressed gasket thickness.

The flanges were gasketed with an Armstrong beater-saturated asbestos material—Accopac AN-890—in 1/32" gauge. (Previous tests had indicated that this material possessed excellent torque retention characteristics.) The only variables in the tests were bolt length and initial torque values.

After the bolts were torqued to specific loads at room temperature, the flanges were placed in an oven at 300° F. for a period of 18 hours. Then they were removed, and while the flanges were still hot, bolt torque was re-measured. The percentage of retained torque was calculated and charted as shown in Figure 2.

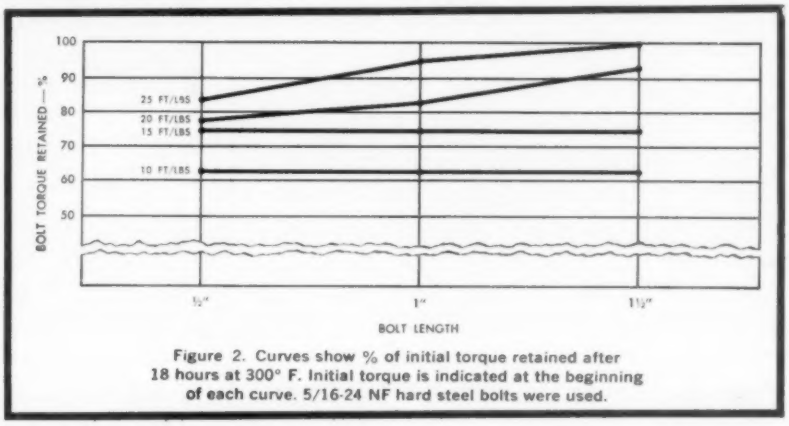



Figure 2. Curves show % of initial torque retained after 18 hours at 300° F. Initial torque is indicated at the beginning of each curve. 5/16-24 NF hard steel bolts were used.

The chart shows clearly that low initial torque loads lose proportionately more torque than higher loads. At 10 ft-lbs of initial torque, for example, the average torque loss for the three bolt sizes was 37%. But at 25 ft-lbs of initial torque, the average loss was only about 8%.

The tests also indicate that longer bolts retain torque much better than short bolts . . . and the difference is greater as initial torque is increased.

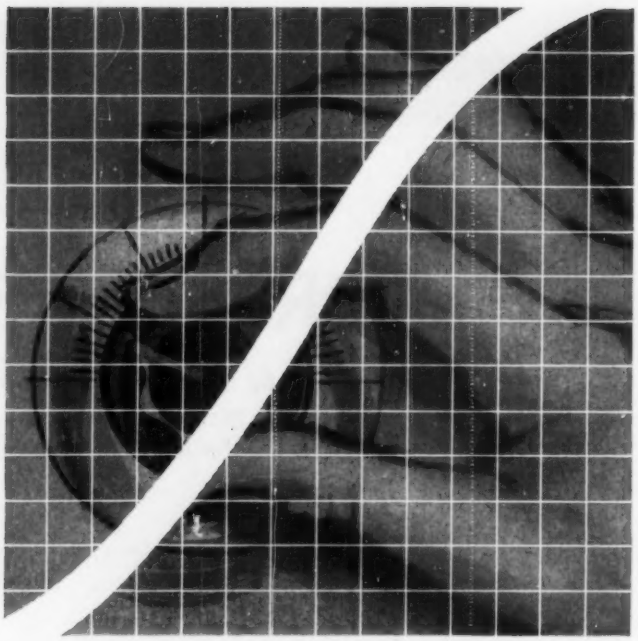
These results are, of course, what was anticipated in quality. In quantity, however, the difference in torque retention resulting from variations in bolt length and initial torque values was significantly larger than had been expected.

Research on gasket performance is a continuing project at the Armstrong Research and Development Center. Our large library of data may already contain the answer to specific problems you may have on gasket design, performance, or selection. We will be glad to make suggestions if you will submit details to us. Address inquiries to Armstrong Cork Company, Industrial Division, 6506 Irvin Street, Lancaster, Pennsylvania.

Armstrong GASKET MATERIALS

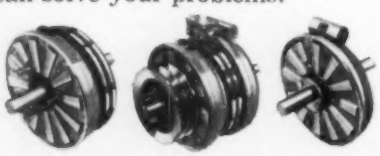
# Warner electric brakes and clutches

**with stepless torque modulation may be the answer to your drive problems**

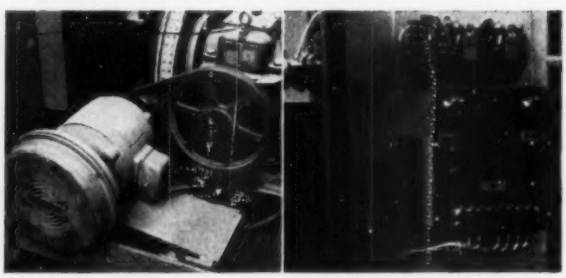


By simply varying the voltage to a Warner electric brake, clutch, or clutch-brake—you can have full-range stepless control flexibility. Just by turning a potentiometer dial on the Warner control, torque may be varied over a wide range during the first few seconds of engagement. Some companies offer adjustable torque as an extra feature for tailoring power characteristics to job requirements. Others have found it to be the solution to difficult control problems, such as synchronized engagement and disengagement of interrelated power drives.

Warner electric brakes and clutches are used for fast starting . . . synchronizing . . . automatic coupling . . . high-speed cycling . . . indexing . . . jogging . . . interlocking . . . and for scores of other power drive control applications. Write today—find out how they can solve your problems!



Primary clutches, clutch-brakes, brakes to 100 hp.



Warner Motor Brake | Warner Control Panel

## example:

Two different braking torques from the same electric motor brake. When hoisting concrete blocks, not much braking torque is needed—yet when lowering pallets, a full braking action is necessary. Warner motor brake on this elevator drive may be actuated through either of two potentiometers. One is set at low voltage and the other at high voltage. Thus, two different braking torques are obtained by actuating the brake through relays, controlled by the *up* or *down* cycle of the elevator. Standard controls are used throughout.

WARNER ELECTRIC

**WARNER ELECTRIC**

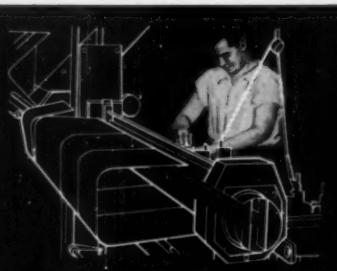
**Warner Electric Brake & Clutch Co., Beloit, Wisconsin**

Stocked by Distributors in Principal Cities Throughout the World

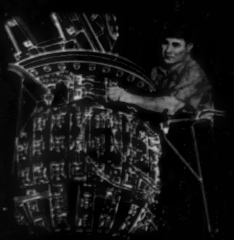
## CHROMALOX ELECTRIC STRIP HEATERS

### Versatile, dependable, uniform heat for your product or processing needs

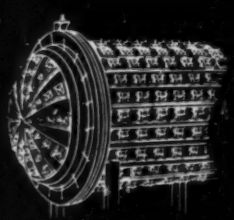
Chromalox Strip Heaters, sheathed in iron, chrome steel and Monel, come in sizes and types for every need. 4" to 96" lengths; 1" to 2½" widths. Also available in full rings and segments.



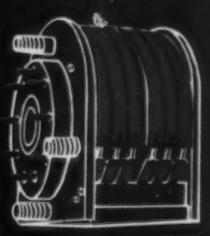
Rolls for bending plywood to form luggage case bodies are uniformly heated with long Chromalox Strip Heaters.



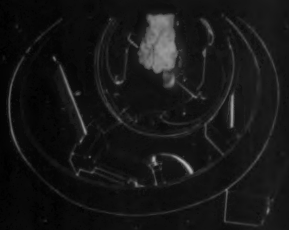
Zoned heat and close temperature control is obtained in grease kettle with separate groups of Strip Heaters.



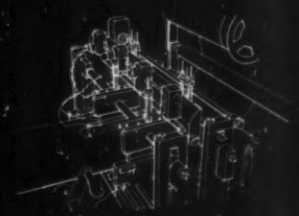
Vacuum dehydrating oven, also used as vacuum furnace at temperatures to 950° F., equipped with Type SE Strip Heaters and SR segment heaters.



Aluminum extrusion container heated by curved Strip Heaters around circumference and Chromalox Cartridge Heaters in holes closer to billet.



Brake-lining bonding oven equipped with three SE Strip Heaters and a Ring Heater to produce uniform bond.

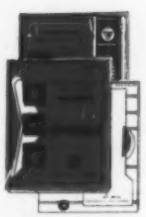


Sealing arm on platen with thermostatically controlled Strip Heaters on each side delivers constant temperatures regardless of machine speed.

Compact, metal-sheathed Chromalox Strip Heaters assure accurate temperatures, dependable around-the-clock service anywhere heat is needed for product or process. It is by far the most versatile built-in heat source available today. Easy to install—Chromalox Strip Heaters produce uniform and accurate temperatures with automatic or manual controls.

Low initial cost, low installation costs and low operating costs are among the many other advantages of using Chromalox Strip Heaters for heating tanks, platens, ovens, molds, moving parts, and similar uses. Over 500 standard sizes, shapes, ratings and terminal arrangements available immediately from stock. Get the full details now.

**GET THE FACTS**
**Write for Industrial Processing Catalog 60, Comfort Heating Catalog F-975D, Infrared Catalog G-62.**

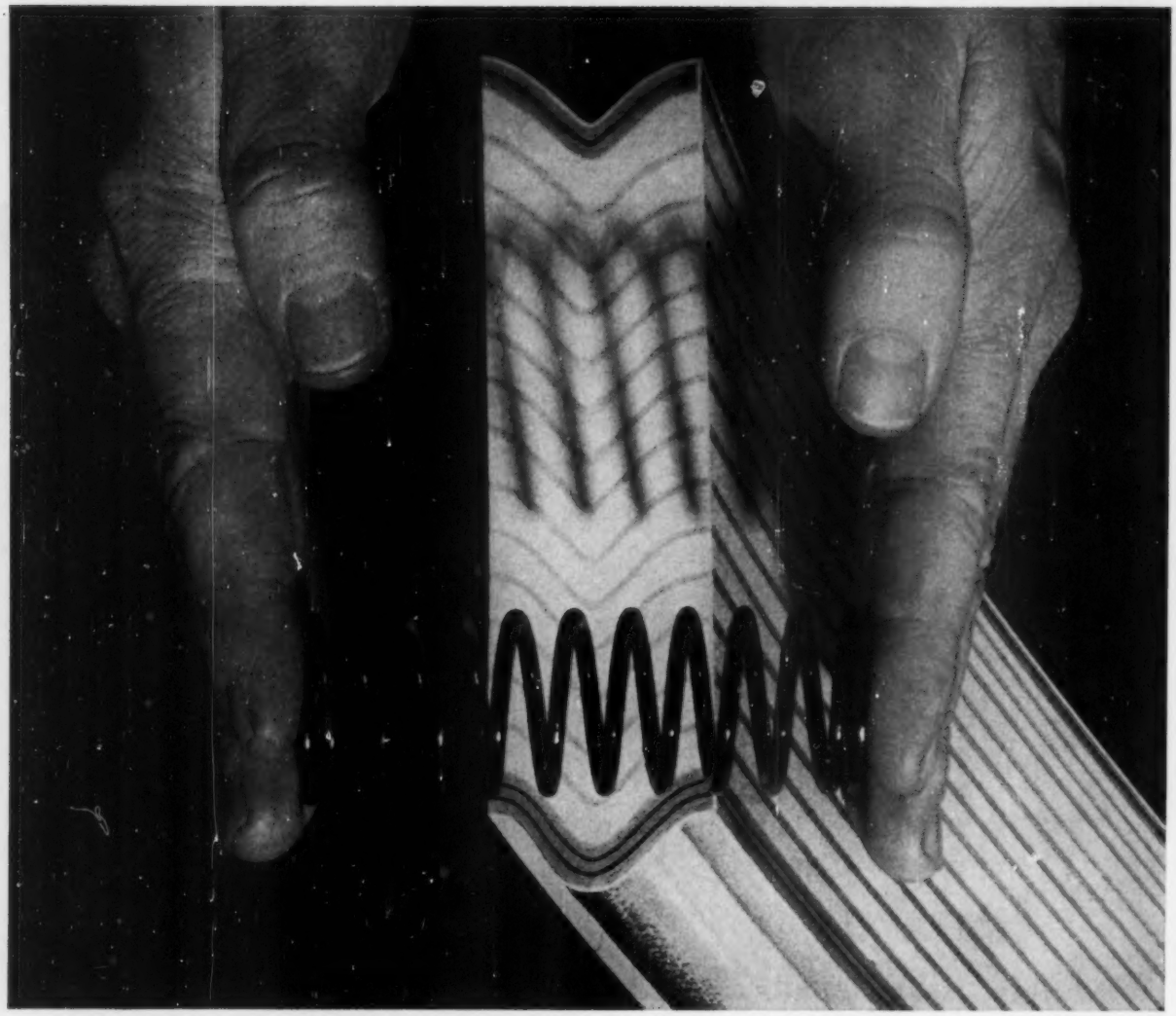


W1-10

**EDWIN L. WIEGAND COMPANY**
**7535 THOMAS BLVD., PITTSBURGH 8, PA.**

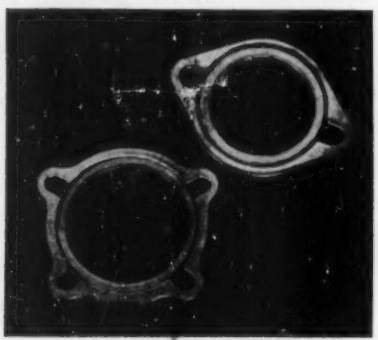
**CHROMALOX**
**ELECTRIC HEAT**

**PROCESS COMFORT**



# "Spring Action" gives you a leakproof seal with J-M SPIROTALLIC® GASKETS

Johns-Manville makes a specialty of building a lively "spring action" into Spirotallic Gaskets. Because of their superior resiliency, Spirotallic Gaskets can compensate for varying stresses and temperature changes ... follow minor flange separation ... and absorb vibration. Even under these difficult circumstances, they keep a tight, durable seal.



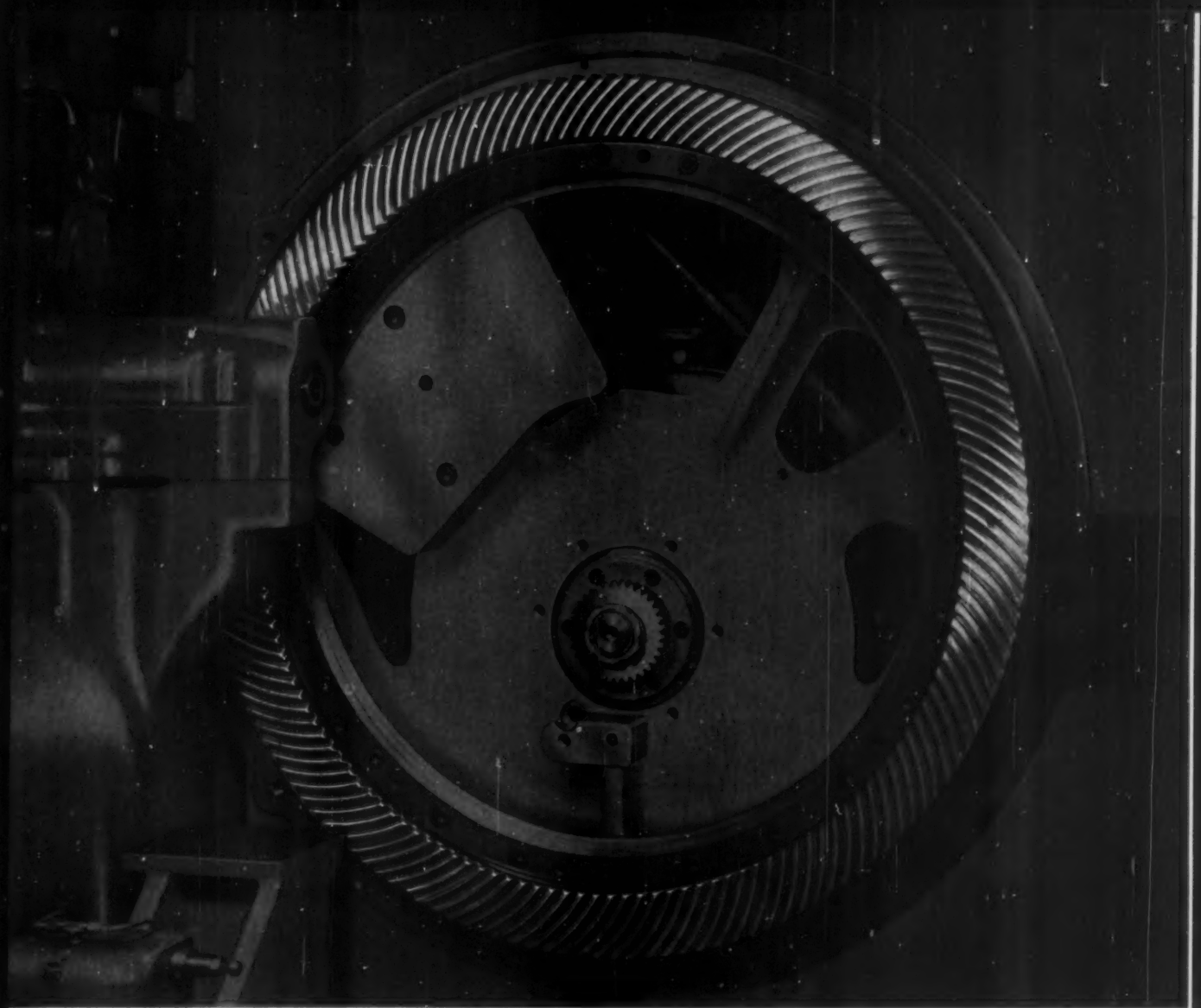
*Examples of wide range of styles available*

This quick adaptability has given Spirotallic Gaskets a tremendous popularity in the field. Their springiness is due to the special methods and control J-M uses in their manufacture. Spring-like metal strips, formed into a special vee shape, are alternately spiral-wound with an asbestos filler. The filler does the sealing . . . and the vee shape provides the "spring."

Another reason for the widespread acceptance of Spirotallic Gaskets is the fact that when the gasket has been compressed the proper amount, it reaches optimum performance for the bolting. Many different metals and fillers can be used. Each metal is color-coded to aid maintenance personnel in quick identification of the type of metal used.

J-M produces a wide variety of sizes and shapes for standard flanges. And for special flanges, J-M will design and produce a gasket with the precise characteristics you require. For complete information, ask for J-M catalog PK-35A. Write to Johns-Manville, Box 14, New York 16, N. Y. In Canada: Port Credit, Ontario.

JOHNS-MANVILLE JM PRODUCTS



# You can get high reductions with Gleason HRH* gear sets

This thirty-one-inch gear and its pinion have a 150 to 5 ratio. Yet they are hypoids — what we call HRH or high reduction hypoids.

These compact, flexible sets can be built to ratios as high as 360 to 1 without losing the traditional advantages of Gleason design proportions.

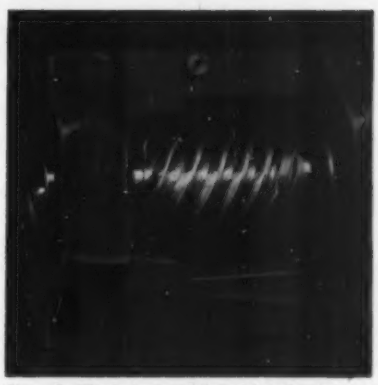
They permit you to design to tight space limits, particularly on big jobs.

They have a typically fine Gleason surface finish, impossible to get with hobbing or other methods. The pinion teeth *wrap around* the pinion, so you get continuous tooth action even with a one-tooth pinion. The resulting motion is always smooth and continuous.

You use regular Gleason machines to manufacture these gears . . . in small quantities and large.

And with all that you get the usual complete technical assistance from our engineering staff . . . all the way through the design stages on to prototypes and full production.

Find out what HRH gears can do for your transmissions by contacting us directly.



**The cylindrical shape of the pinion lends itself readily to straddle mountings. The high offset design also increases the diameter of the pinion, lending extra strength to the entire assembly.**

*Trademark for Gleason High Reduction Hypoids

**GLEASON WORKS**

1000 UNIVERSITY AVE., ROCHESTER 3, N. Y.

92

**CIRCLE 39 ON READER SERVICE CARD**

One in a series of technical reports by Bower

BEARING BRIEFINGS

# ROLLER GUIDANCE– VITAL FACTOR IN BEARING LIFE

**Roller guidance has been established by the Anti-Friction Bearing Manufacturers Association as a major rating factor for roller bearings. There is a direct relationship between this factor and the life and capacity of a cylindrical roller bearing under load.**

Figure 1 illustrates the results of a loose fit between a roller and the guiding ribs of the raceway. Because of lack of guidance by the ribs, the roller is free to skew and skid under load. Such a condition invariably leads to early bearing failure.

To achieve close roller fit and proper roller guidance, Bower precision grinds each bearing race on specially designed centerless grinders. In this operation, Bower positions the integral raceway ribs *from the theoretical centerline of the bearing*. This method produces bearings with high dimensional accuracy and perfect symmetry.

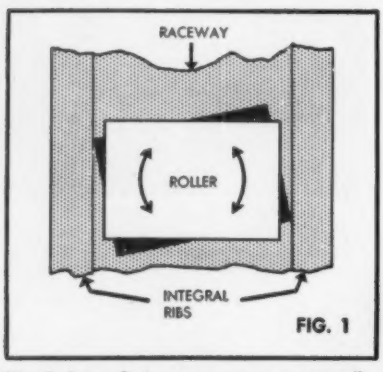
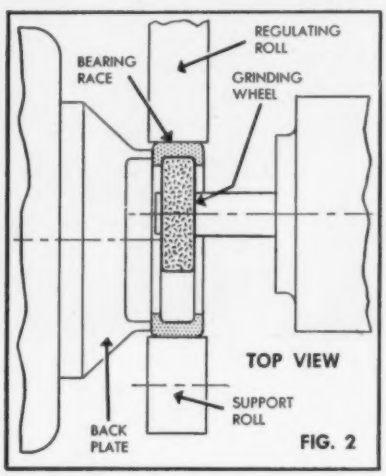
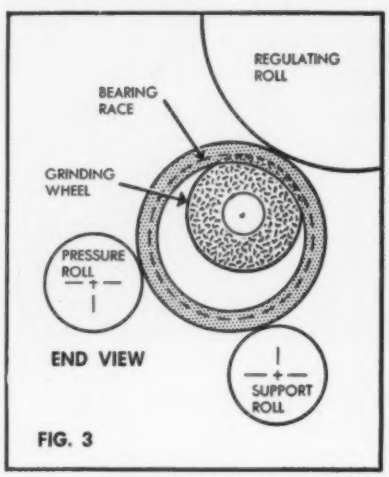



**Fig. 1.** Loose fit in raceway means poor roller guidance. Roller can skew and skid under load.

In addition, the close tolerances held in grinding the roller track and integral guiding ribs give Bower cylindrical roller bearings the ability to *take thrust in any direction*. A Bower cylindrical roller bearing has thrust capacity of from 10-15% of its rated radial capacity!




Figures 2 and 3 diagram the centerless grinding method used to finish Bower raceways. Use of this technique assures not only optimum roller guidance and maximum bearing life, but also virtually eliminates bearing runout. BEARING SYMMETRY WHICH RESULTS FROM THIS TECHNIQUE PERMITS ACCURATE SHAFT LOCATION REGARDLESS OF HOW THE OUTER RACE AND ROLLER ASSEMBLY ARE INSTALLED. IT COMPLETELY ELIMINATES THE POSSIBILITY OF IMPROPER INSTALLATION.




★ ★ ★ ★

*Whatever your bearing needs, we suggest you consider the advantages of Bower bearings. Where product design calls for tapered or cylindrical roller bearings or journal roller assemblies, Bower can provide them in a full range of types and sizes. Bower engineers are always available, should you desire assistance or advice on bearing applications.*

BOWER ROLLER BEARINGS

BOWER ROLLER BEARING DIVISION – FEDERAL-MOGUL-BOWER BEARINGS, INC., DETROIT 14, MICHIGAN

# OPENING NEW HORIZONS

*. . in economical power application*

98% PLUS OPERATING EFFICIENCY
MORE POWER PER CYLINDER DOLLAR
PROVEN LEAKPROOF OPERATION
GREATEST SELECTION EVER OFFERED
SAFE UNDER SEVERE LOADS
SAFE WITH ALL KNOWN HYDRAULIC FLUIDS
SAFE UNDER TEMPERATURE EXTREMES
DAMAGE PROOF PISTON RODS

**ller**
**HYD AULIC**
**CYLINDERS**

Flick-Reedy . . . *Winner of "Plant of the Year" Award and "Silver Anvil" Public Relations Award*

Miller

**MORE SAVINGS!**

Our ultra-modern, new "Plant of the Year" with its special facilities and operating economies enable us to offer an **extra 10% price savings** on our big "stock" selection of:
Model "H" (Hyd.) Cylinders, 1½" through 8" bores;
Model "J" (Hyd.) Cylinders, 1½" through 14" bores;
Model "A" (Air) Cylinders, 1½" through 14" bores.
Strokes up to 36", cushioned and non-cushioned.

**Full Details On Request**

Miller Hydraulic Cylinders make impossible applications look easy. With Teflon Seals, Case-Hardened Rods (50-54 Rockwell C), Patented "Shef" Tubing End Seals, and other exclusive *standard* features, these cylinders are practically damage-proof, are ultra-dependable under pressure and temperature extremes, and provide leakproof sealing with ALL hydraulic fluids. Built to *exceed* J. I. C. Specifications, these cylinders are achieving new highs in production and operating economies in thousands of plants. Two great lines: Power-Packed Model H for 3000-5000 psi and Job-Rated Model J for 500-2500 psi. All bores, strokes and mounting styles. Big "Stock" selection for immediate shipment at substantial savings.

*Write for literature.*

R

## MILLER FLUID POWER

DIVISION OF FLICK-REEDY CORPORATION

**7N018 York Road, Bensenville, Illinois**

AIR AND HYDRAULIC CYLINDERS · ACCUMULATORS
COUNTERBALANCE CYLINDERS · BOOSTERS

**7' BOAT** (SPORTYAK*, Dayton Bait and Marine Products Co., Dayton, Ohio)—This boat of MARLEX is tough, rigid, unsinkable, lightweight . . . never needs painting. (*A trademark of Woodall Industries, Inc., Detroit 34.)

**LAWN MOWER** (Jacobsen Mfg. Co., Racine, Wis.)—Grass chute, engine cowling, and wheel hubs of MARLEX are light, tough, and corrosion-free . . . add performance and sales appeal to this popular line of lawn mowers.

**POST LANTERN** (Western Circle Co., Hazelwood, Mo.)—This "Cape Codder" has established sales appeal. Because of MARLEX . . . it's unaffected by weather, can't rust, keeps color and lustre without painting.

**ROPE** (Plymouth Cordage, Plymouth, Mass.)—Available in many sizes and colors, rope made of MARLEX is stronger and lighter than manila . . . it floats, does not absorb water or freeze . . . resists most chemicals.

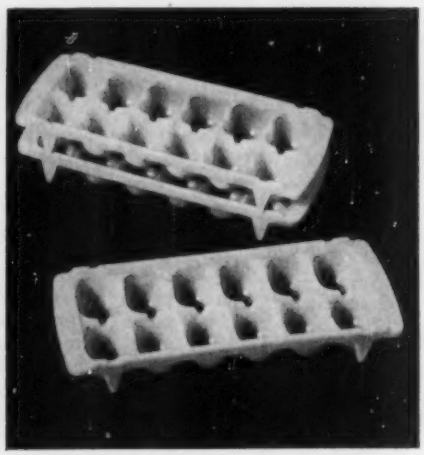
# MARLEX* improves product performance . . . increases sales appeal

Shown here are examples of the increasing number of hardware, lawn and garden equipment, sporting goods, and housewares being "quality upgraded" by the use of MARLEX high density polyethylenes and ethylene copolymers. Boats that will never rot . . . rope and bulk bags that are lighter, stronger and moisture-proof . . . outdoor items that cannot corrode—all made of tough, durable, virtually indestructible, economical MARLEX.

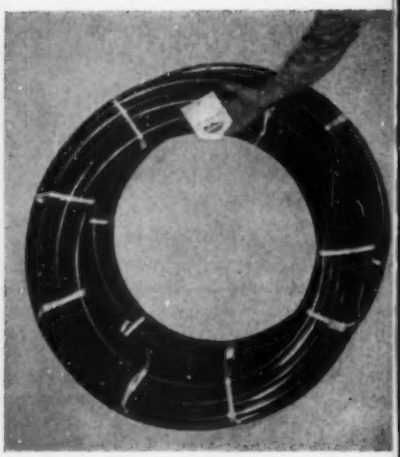
MARLEX high quality plastics are lightweight, tough, rigid or flexible . . . resistant to acids, alkalies, greases, fungi, and corrosion . . . and possess a wide usable temperature range (—180°F to 250°F).

*MARLEX is a trademark for Phillips family of olefin polymers.

**NURSERY PRODUCTS BAG** (Crystal-X Corp., Lenni Mills, Pa.)—For private-branding your bulk supplies. Bags made of MARLEX are lighter, tougher, moisture-proof and less apt to tear or burst. Easy heat sealing.



**POP OUT ICE CUBE TRAY** (The Dole Valve Co., Morton Grove, Ill.)—New design and MARLEX cause cubes to "pop out" without "defrosting". Tray is flexible even when ice-cold . . . and tough, sanitary, longer lasting.



**MERCHANT PIPE**—Available from ½" to 2", this easy-to-install coilable pipe of NSF approved MARLEX has a wide temperature range and extra strength per mil of wall thickness. Quality at moderate cost!

*For more information, see your plastic fabricator, or contact us.*

## PHILLIPS CHEMICAL COMPANY

**Bartlesville, Oklahoma**

*A subsidiary of Phillips Petroleum Company*

PHILLIPS 66 MARLEX PLASTICS

**CIRCLE 42 ON READER SERVICE CARD**

# HYDRECO

*out front in . . .*

# PRODUCTION QUALITY CONTROL

. . . JUST ONE MORE WAY HYDRECO SERVES YOU BETTER!
Modern gaging equipment — like these units for checking critical dimensions — is an important factor in the reliable quality control provided by Hydreco. Such equipment is used at every stage of the manufacturing process.

But Hydreco quality control does not stop there. To insure precision made products, master gages are also used to double check the accuracy of production gages!

This gaging equipment is just one more reason why Hydreco continues to lead in the essential areas of quality and performance. It's also one of the big reasons why — when it comes to Hydraulic equipment — more and more companies are switching to Hydreco . . . the one that serves you best.

**HYDRECO®** DIVISION
THE NEW YORK AIR BRAKE COMPANY
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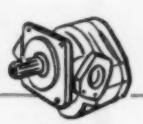
PUMPS

VALVES

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CIRCLE 43 ON READER SERVICE CARD

# A SALES-BUILDING IDEA FOR YOUR PRODUCTS, TOO

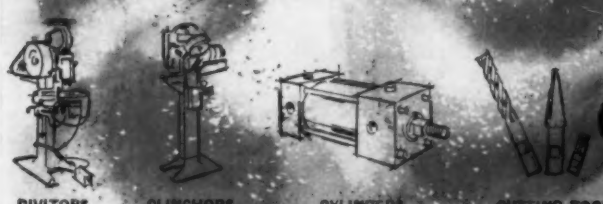
This exceptional vinyl can be laminated permanently to metal for an integral finish of distinctive color and design! That's its beauty as a selling plus. And here's its beauty from a *production* standpoint: It can be cut, crimped, drilled or deep-drawn without impairing its beauty or distorting the material. No new processing equipment needed. Enables you to work with prefinished parts. Can even eliminate the need for spray booths and baking ovens. Cleans easily. Write for information and samples.

Industrial Products Division
**THE MASLAND DURALEATHER CO.**
Dept. PE-E, Amber & Willard Sts.
Philadelphia 34, Pa.

Furniture by FALCO PRODUCTS CO., Philadelphia, Pa. Masland Duran Clad used on table. Matching upholstery grade Masland Duran on chair.

# BIG NEWS

The T-J Spacemaker cylinder line is not now, nor ever has been, a probe into outer space. It is offered as a practically designed, research engineered and time tested product. Its Spacemaker feature (no tie-rods) and rugged construction gives greater strength, saves space and reduces costs in all power drive applications. The Spacemaker is available in a complete range of bore sizes and strokes, air or hydraulic, and contains many *plus features* and extras as STANDARD . . . NO EXTRA COST! Write Tomkins-Johnson, 2425 W. Michigan Ave., Jackson, Mich. for Bulletin #155-4 and for full particulars, today.




T-J TOMKINS-JOHNSON
JACKSON, MICHIGAN

# HANDY ALLOY DATA SHEET

HANDY & HARMAN ENGINEERING DEPARTMENT
850 THIRD AVENUE, NEW YORK 22, N. Y.

TEC and TEC-Z

## ...How to choose between a soft solder and a brazing alloy

Handy & Harman provides *two* alloys that fit between "something stronger than the average soft solder but not as strong as a silver-brazing alloy." They are named TEC and TEC-Z and their flow points are intermediate between soft solders and silver-brazing alloys. Joints made by these alloys are strong in straight tension or shear. For instance, butt joints of cold-worked copper can be made having a tensile strength of about 25,000 psi. This is approximately 10,000 psi. more than can be obtained with tin-lead soft solders. TEC joints retain their strength at elevated temperatures much better than the tin-lead soft solders. As shown in the table below, the strength of the solder itself at 425° F is about the same as a 50% tin–50% lead solder at room temperature in short-time tensile tests.

*Applications*—One example is a thermostatic bellows where the operating temperature is too high for soft solders (tin-lead), yet requires a joining medium which will not anneal the bellows. Another use is gun parts which require joint strength at higher than soft-solder operating temperatures *plus* corrosion resistance to solutions used in cleaning and blackening. Also for lamp bulb bases operating at approximately 350°-500° F. Automotive applications and heat exchangers. TEC conforms to Government Specifications Mil-S-19234 (Nord); both TEC and TEC-Z are available in sheet, wire, powder, and preforms to specifications.

### NOMINAL COMPOSITIONS

| | TEC | TEC-Z |
|---|---|---|
| Silver | 5% plus or minus 0.5% | 5% plus or minus 0.5% |
| Zinc | | 16.6% plus or minus 0.5% |
| Cadmium | 95% plus or minus 0.5% | 78.4% plus or minus 0.5% |

### PHYSICAL PROPERTIES

| | TEC | TEC-Z |
|---|---|---|
| Color | White | White |
| Melting Point | 640° F | 480° F |
| Flow Point | 740° F | 600° F |
| Density (Troy oz/cu in.) | 4.60 | 4.53 |
| Electrical Conductivity (Cu=100) | 22.0% | 20.6% |
| Electrical Resistivity (Microhm-cm) | 7.9 | 8.4 |

### STRENGTH COMPARISON TEC vs. Pb-SN

| | TENSILE STRENGTH LBS/SQ IN. | TENSILE STRENGTH LBS/SQ IN. |
|---|---|---|
| | TEC | Pb-SN |
| ROOM | 16,400 | 2,500 |
| 300° F | 4,400 | 650 |
| 425° F | 2,600 | Melts |
| 500° F | 1,700 | |

The information and data on this page are available in our Handy Alloy Data Sheet. Ask for "TEC." Handy & Harman, 850 Third Ave., New York 22, N. Y.

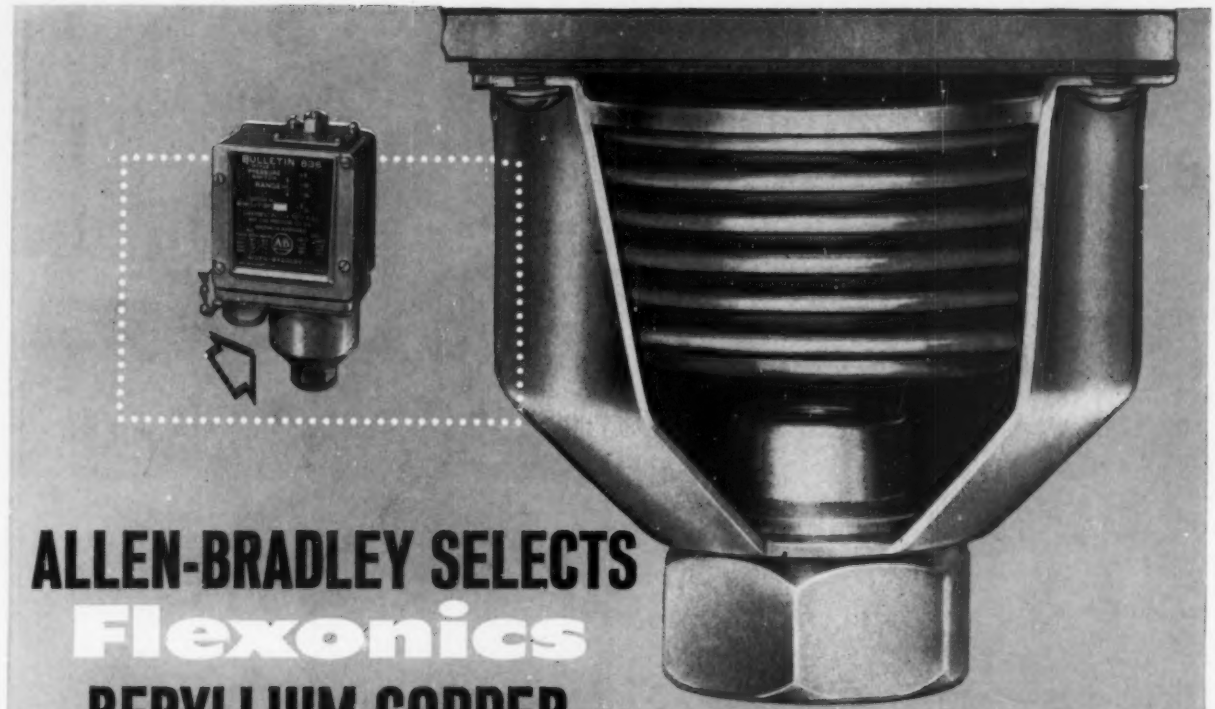
*Your No. 1 Source of Supply and Authority on Brazing Alloys*

**HANDY & HARMAN**

General Offices: 850 Third Avenue, New York 22, N. Y.

Offices and Plants: Bridgeport, Conn. • Chicago, Ill. • Cleveland, Ohio • Dallas, Texas • Detroit, Mich. • Los Angeles, Calif. • New York, N.Y. Providence, R. I.. • Montreal, Canada • Toronto, Canada

*DISTRIBUTORS IN PRINCIPAL CITIES*



# ALLEN-BRADLEY SELECTS Flexonics BERYLLIUM COPPER BELLOWS

***for longer life . . . higher pressures***

Beryllium copper was selected as the metal for the Flexonics bellows in the new Allen-Bradley Bulletin 836 Style T Oiltight Pressure Control. Advantages gained include . . . longer cycle life . . . ability to withstand higher pressure . . . and negligible hysteresis for up to 80% of compression stroke. Specifications of the Allen-Bradley Style T Pressure Control are: Adjustable range 0 to 35 psi . . . adjustable differential 1½ to 7 . . . maximum allowable pressures 60 psi (line), 80 psi (occasional surge).

**OTHER FLEXONICS BELLOWS**

FLEXONICS CAN HELP YOU. If you are confronted with a problem involving absorbing, compensating, transmitting, or converting energy or force, your answer may well be a bellows. A good source of counsel is the Flexonics Application Engineering Staff. These men are experienced in all areas of bellows application from the simple sensing device of the domestic range to highly intricate and delicate fluid metering controls for missile engines. Flexonics bellows can be furnished in a broad range of metals. You are invited to submit your problem for analysis—without obligation.

B-540

**Flexonics**

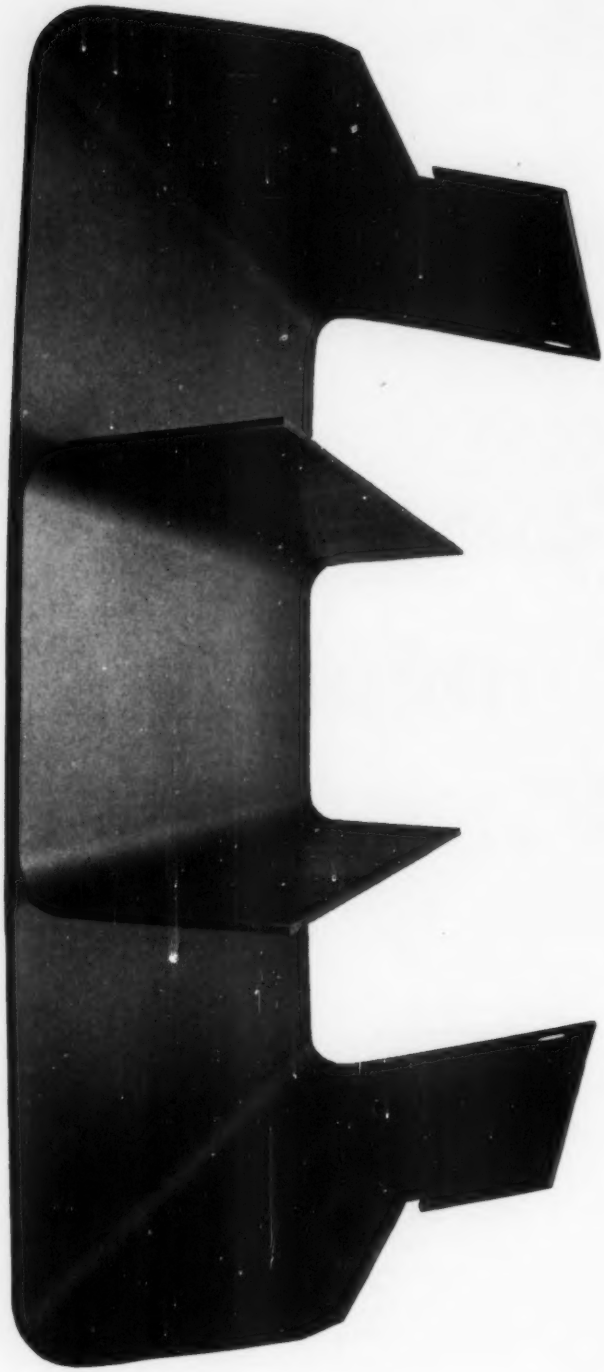
DIVISION OF CALUMET & HECLA, INC.
386 East Devon Avenue • Bartlett, Illinois

FLEXIBLE METAL and SYNTHETIC HOSE EXPANSION JOINTS
BELLOWS • SPECIAL TUBULAR ASSEMBLIES

In CANADA
FLEXONICS CORPORATION OF CANADA, LTD.
BRAMPTON, ONTARIO

Flexonics
386 East Devon
Bartlett, Illinois

Please send my personal copy of Flexonics 20 page Bellows Design Guide covering in detail Flexonics products and services for bellows applications.



**Practical approach to compactness** is demonstrated by this flame retardant, interphase insulating barrier for magnetic air circuit breakers. When the equipment was designed, CDF utilized its extensive knowledge of adhesives and post-forming to provide the barriers from a flame retardant, paper base phenolic laminate.

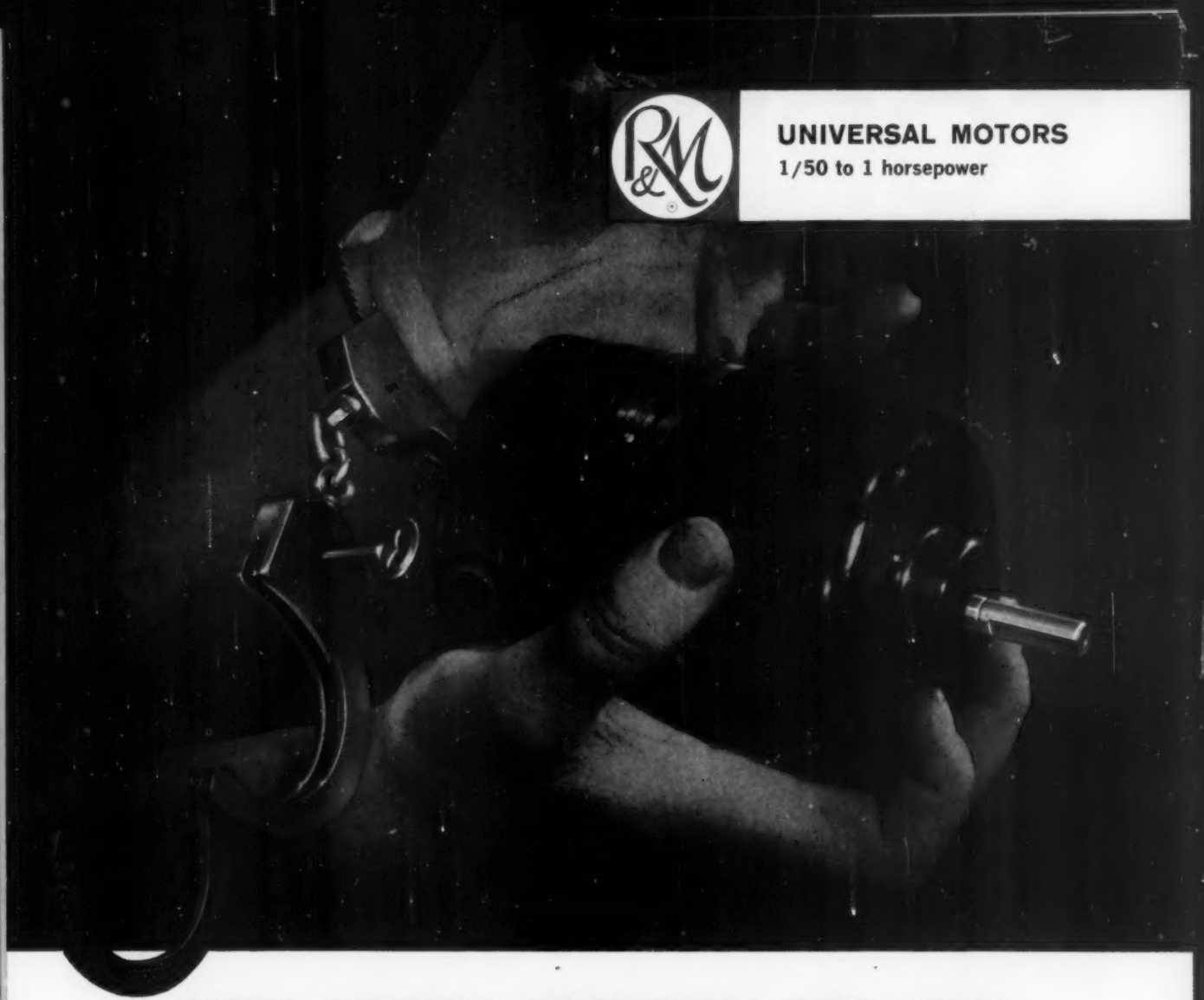
**Result:** two pieces bonded together to provide three channels in one unit, reducing size and cost, yet maintaining effective electrical insulating properties.

**A few facts on the laminate:**

Flame resistance: ASTM D-635
... self extinguishing
Water absorption, % . . . . . 1.8
Flexural strength, psi . . . . . 12,000
Specific gravity . . . . . 1.38
Dielectric strength, parallel, kv . . . 40

CDF® CONTINENTAL-DIAMOND FIBRE

CONTINENTAL-DIAMOND FIBRE CORPORATION, NEWARK, DELAWARE • A SUBSIDIARY OF THE Budd COMPANY



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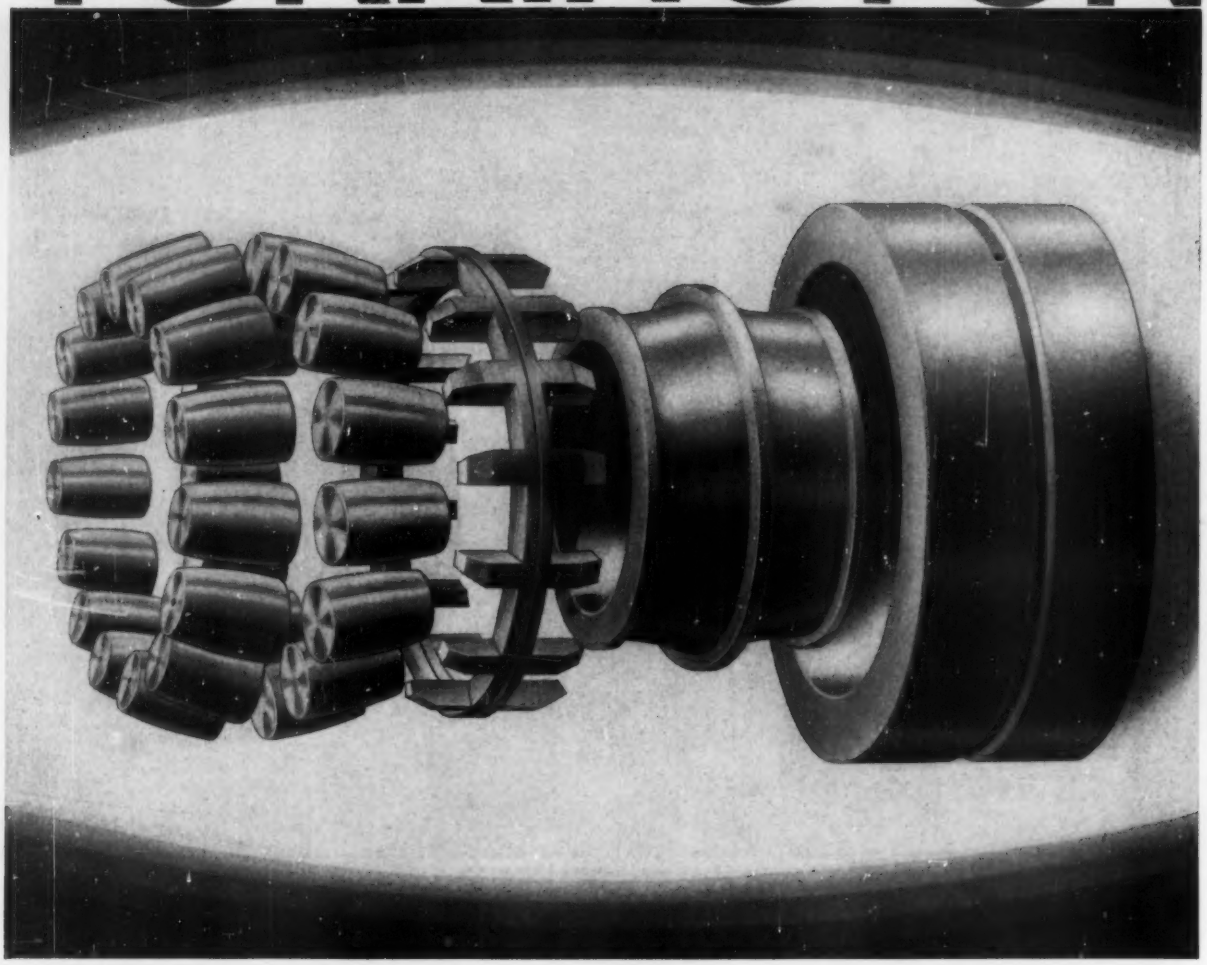
**CIRCLE 49 ON READER SERVICE CARD**

# TORRINGTON



## FOR THE INSIDE STORY...

...ON TORRINGTON SPHERICAL ROLLER BEARINGS, one word: *precision.* Each individual part is precision-engineered to the highest standards in the industry...functions precisely and efficiently with all other parts.

Every roller is matched electronically within .0001" for even-load distribution and maximum capacity.

Each independent land-riding cage spaces rollers precisely...prevents roller drag even under the heaviest loads and possible misalignment.

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Put together...a Torrington Spherical Roller Bearing for superior performance, reliability and long service life. Buy the best...specify Torrington.

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- ☐ integral center guide flange for stability
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- ☐ maximum radial and thrust capacity
- ☐ controlled internal clearance
- ☐ electronically selected rollers
- ☐ even load distribution
- ☐ long, dependable service life

*progress through precision*

**TORRINGTON BEARINGS**

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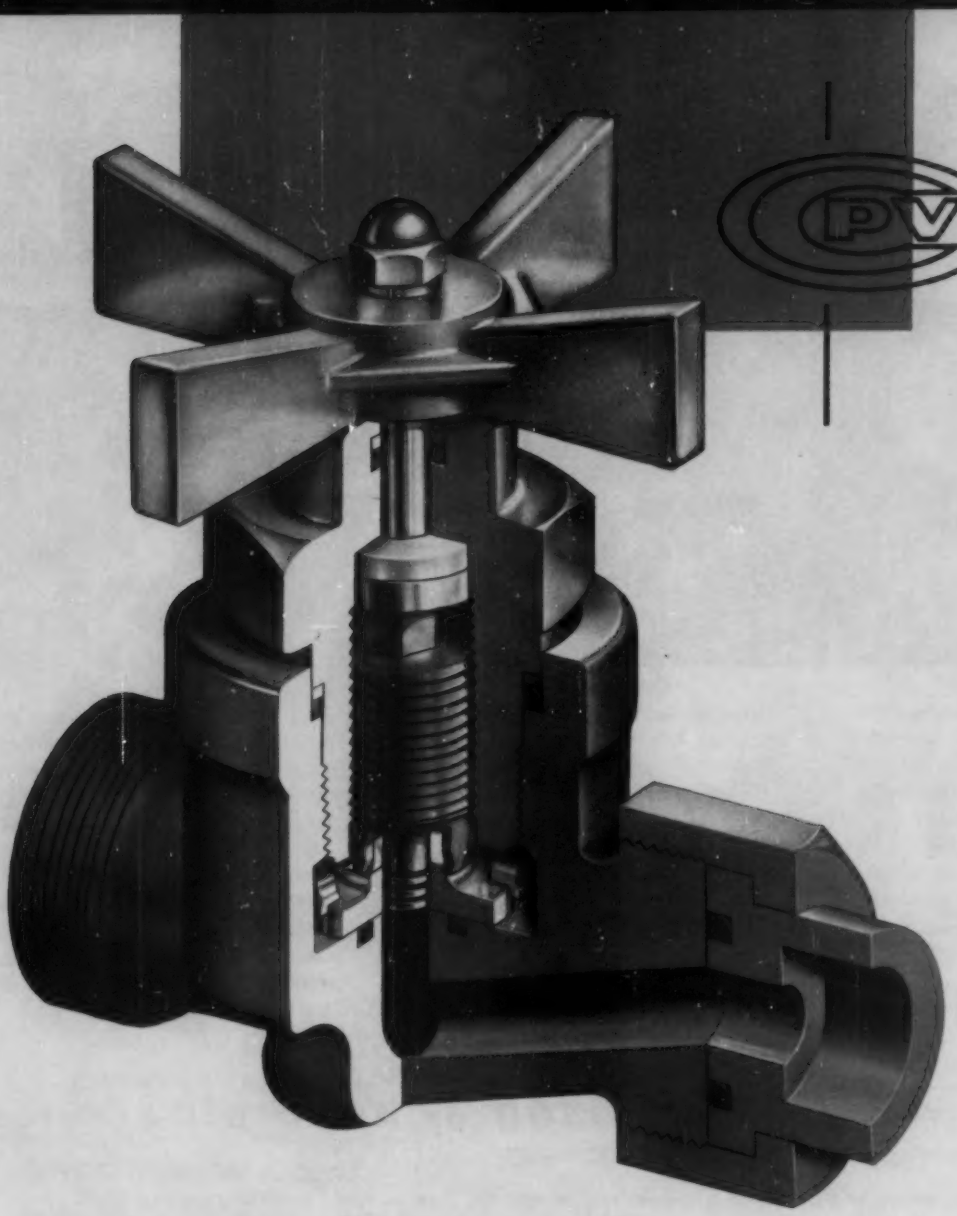
**CIRCLE 51 ON READER SERVICE CARD→**



## THIS HIGH PRESSURE SYSTEM HAS MADE ALL OTHERS OBSOLETE!

And for good reason. Leakage can't be tolerated when line pressure soars to 6000 psi. The CPV O-SEAL SYSTEM not only satisfies this critical requirement, but provides a degree of design flexibility previously unavailable even for low pressure applications.

Leakproof connections are made – or broken–at will, and they remain leakproof regardless of vibration or line surge. CPV design employs O-rings as static seals that *use* line pressure to effect a perfect seal. In fact, the higher the pressure, the tighter the seal.

Valve packings, a constant source of maintenance, have been completely eliminated.

"Bubble-tight" valve shut-off is assured every time by combining a resilient nylon disc with a monel valve seat.

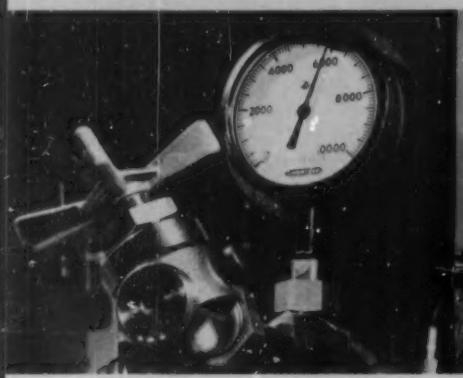
The reliability of CPV soft-seated valves and the effectiveness of O-ring sealing have been proven by certified government tests. In one of these, a CPV O-SEAL valve showed no sign of leakage at over 4000 psi after more than 4500 successive closures!

Also, the CPV O-SEAL SYSTEM is so flexible that you can assemble, remove, relocate or modify any section or the complete system without springing or cutting the lines.

Turn the page for more details on this proven breakthrough in high pressure system design . . .

# O-SEAL SYSTEM
*for high pressures*

***"Bubble-Tight" at 6000 psi . . . Proved by the Nuclear Subs . . . Handtight Connections***



Here's the business end of a CPV O-SEAL valve under test in a 6000 psi line. The thin film of soap solution covering the discharge port proves there isn't any leakage through the valve seat. Unique nylon disc and monel seat design combine to give "bubble-tight" valve shut-off of water, oil and any gas — even "hard to handle" helium.

Ever since the USS George Washington left the drawing boards, the O-SEAL SYSTEM has been specified for handling the critical high pressures on nuclear submarines. This, and a rapidly growing roster of industrial applications, underlines the basic soundness and proven reliability of this unique system for line pressures to 6000 psi.

Just tighten the union nut *by hand* and you have a connection that will be leakproof well above 6000 psi. Even after installation, valve can be repositioned or removed merely by loosening the union nuts. Same principle applies to unions, elbows, tees, and fittings. Unlimited flexibility is assured without sacrificing leak-tight requirements.

## *A Complete System for 1500 or 6000 psi Service*

CPV offers a complete system of O-SEAL valves and fittings to meet a wide range of high pressure design needs at fluid temperatures from −20° to 275°F. Unions, elbows, tees and fittings in addition to globe, check and relief valves are available in sizes ranging from ⅛-inch to 2 inches. Two complete series—for working pressures to 1500 psi or to 6000 psi—provide unequalled design flexibility.

Details and specifications on the full line of CPV O-SEAL valves and fittings are given in 36-page Catalog 60-A. Clip the coupon below to your company letterhead and mail to CPV today for your copy.

Combination Pump Valve Company
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Please send me Catalog 60-A on the CPV O-SEAL SYSTEM

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(Reading from top, left to right)

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Traffic signal lens for street and highway control
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**MARINE** floating light lens
Marine color filter
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**RAILROAD** lantern globe
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Railroad fresnel globe

**SURGICAL** heat absorbing lamp filter

**LIGHTING** refractor for street lighting
Lighting lens—flat fresnel for interior lighting
Lighting museums and art galleries—color-correcting glass
Lighting lens—beam control

**FLOODLIGHTING** cover glass

**INDUSTRIAL** vapor-proof globe
Industrial control board indicator lens
Industrial sight glass

**SWIMMING POOL** color-correcting lens

**THEATRICAL** lighting color filter
Theatrical and TV spotlight lens

**AIRCRAFT** wingtip lens
Airport runway lens
Aircraft wingtip part
Airport runway color filter
Airport runway bi-color lens

**AUTOMOTIVE** turn signal arrow
Automotive dome

**DENTAL** light color-correcting filter

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Whether you need a lens, color filter, cover glass, or some other special part, Kopp can engineer and custom-produce a product to meet that need. It will be designed to provide the right light and color transmission and distribution, heat-resistance, mechanical strength—in fact, the exact combination of properties needed to do your special job. Write us about your needs.

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☐ Enclosing preliminary drawing and application information for your suggestions.

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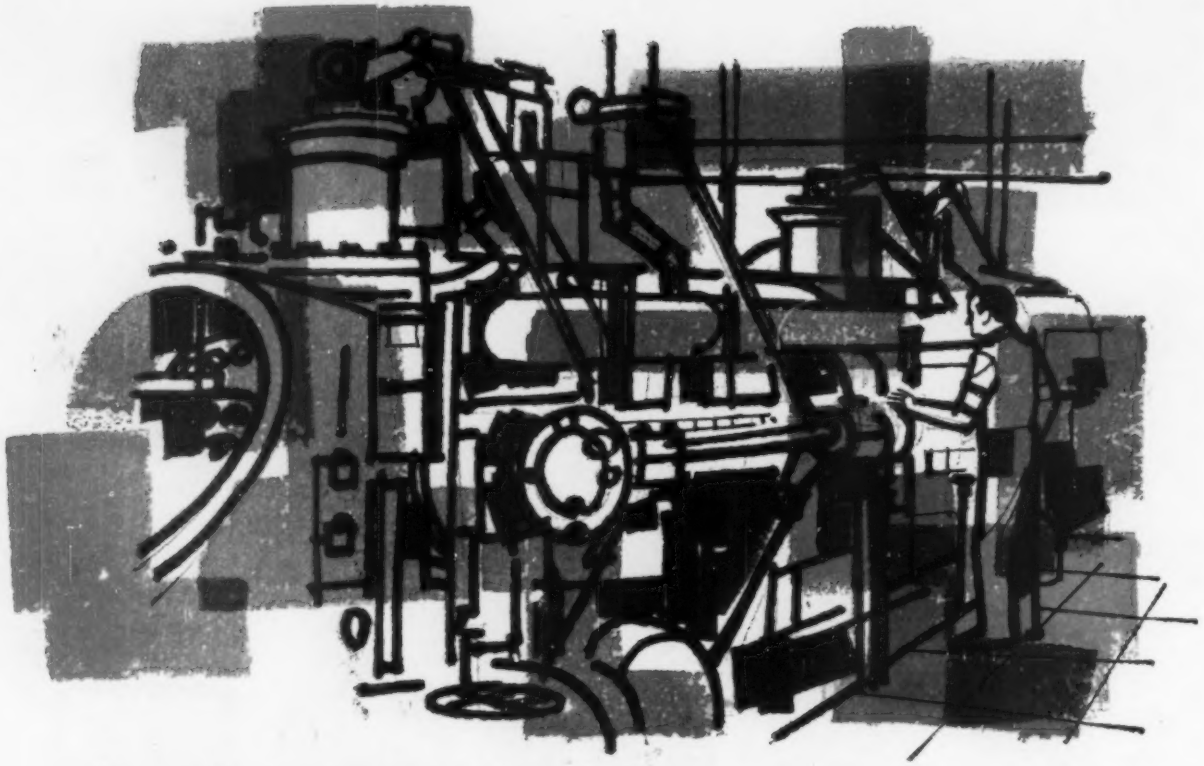
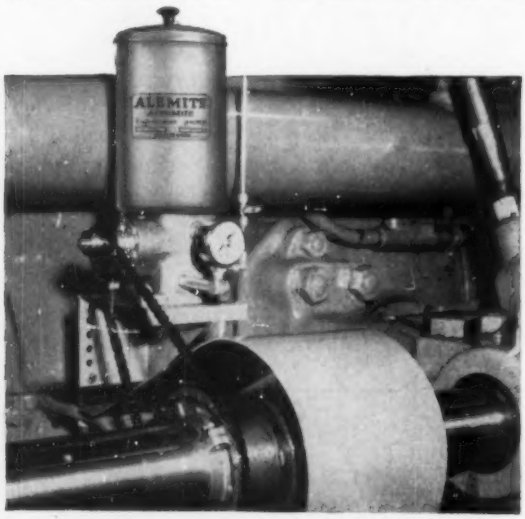
CIRCLE 53 ON READER SERVICE CARD 53



# No other centralized lubrication system can offer the advantages of Accumite with the ALEMITE MECHANICAL PUMP AND TIMER!




Close-up of the Alemite Mechanical Pump and Timer driven by timing shaft by means of a chain and sprocket.

By utilizing a chain and sprocket to transfer rotary motion to an Alemite Mechanical Pump and Timer you can supply efficient, automatic Accumite Centralized Lubrication to as many as 400 points or bearings. That's over 30 times the capacity of other pumps! The Alemite Pump eliminates the "rat's nest" of lines other systems require–serves all bearings with a single line. Shots are measured at the bearing, *not at the pump*. Line length is no factor and any size shot from .00055 oz. to .012 oz. or more can be delivered to any point. Two more Alemite advantages are the big capacity 5-pint reservoir and an alarm system assuring accurate, positive lubrication.

The Alemite Pump and Timer is completely mechanical, uses no air or electricity. Cam operated valve closes at intervals determined by the pump input shaft speed to deliver positive, measured amounts of lubricant to each point in the system. Measurement is by piston stroke, wear not a factor, pressures remain constant and can be read on any type gauge.

Contact your local Alemite distributor or write for free illustrated literature on the Alemite Mechanical Pump and Timer and the Accumite Centralized Lubrication System.

Symbol of SW Excellence

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PRODUCT ENGINEERING HORIZONS

JUNE 12, 1961

# YOU AND TOMORROW

Are there times when you wonder—just a little—how much you really know? Do you sometimes feel that the new crop of engineers has been better trained than you were, that technology is moving too fast for you to keep up?

**Mover over, Brother,** and make room for me! Dr Thomas Stelson of Carnegie Tech estimates that the older graduate must put in 10% of his time developing his knowledge to keep up, an additional 10% to retain his collegiate training. A classmate of mine, who has spent his life in education and is now a very respected dean, told me recently that present-day engineering graduates learn as much in their first two years as I did in four.

**Well, maybe.** But they'll have the same worries and wonders a decade—or two decades—from now, because technological change is accelerating all the time. And much of the recent advance has been in the area of information technology—the kind that moves into the "thinking" phases of engineering. This in turn leads to the possibility that many decisions now made through the wisdom of experienced engineers will be made by pushing the right buttons.

**So what?** A great many men become obsolete within their working lives because they've been graduated into a specialty or into management. They forget the basic things because they no longer use them every day, and they fail to learn the new things because they haven't time or aren't forced. And about the time they'd welcome a little respect for their sagacity, they find their experience is outmoded and worthless. This is the penalty of rapid technological advance.

**Add in the longhairs.** The shift from practical engineering to engineering-science has been extremely rapid these last few years. The longhairs are inheriting the earth. What are you going to do about it? Become a longhair too? Develop countermeasures? Combat the invasion? Try to outlast them? We're rapidly progressing from the era in which a bachelor's degree became essential to one in which the master's is a minimum and a doctorate advisable, particularly in research. Does this trend produce better research, better science, better engineering?

**Again, maybe.** In many cases the shift has just produced involvement, obfuscation, even resistance to new ideas. Because education can be an eye-closer as well as an eye-opener. It can make a man over-emphasize the known, over-value his knowledge, scorn the ideas of less-well trained men. It can build a sense of security where there is no security, a blind belief that erudition and culture will triumph over ignorance and force.

**But they don't.** Our elaborate intelligence setup fell flat on its face in Laos, Cuba and half a dozen other places—and seemingly hasn't improved. Presumably it is manned by well-trained, experienced men. Our diplomacy has failed again and again, is similarly manned by experienced men. Can the same thing be said of our science—and our engineering?

**Can it be said about you?** Or will it be said tomorrow? Will you enter 1971 with a 1961 point of view, as we nationally have entered 1961 with a 1940 point of view?

K. Langenman

SILICONES

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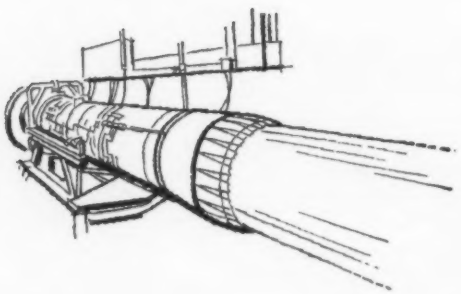
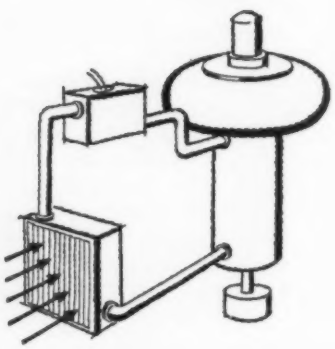
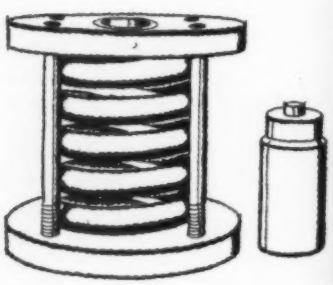
WHICH NEED THE THERMAL STABILITY,
LONG LIFE, CONSTANT VISCOSITY
AND COMPRESSIBILITY OF

# *General Electric Silicone Fluids*







**Extreme temperature lubricants** For high temperature lube applications, General Electric silicone lubricating fluid Versilube F-50 gives unmatched thermal and oxidative stability over the temperature range of —100°F to 600°F. Its lubricity is unequalled at temperatures as high as 600°F, and comparable to other fluids in the moderate ranges. Excellent hydrolytic stability. Not corrosive to common metals.

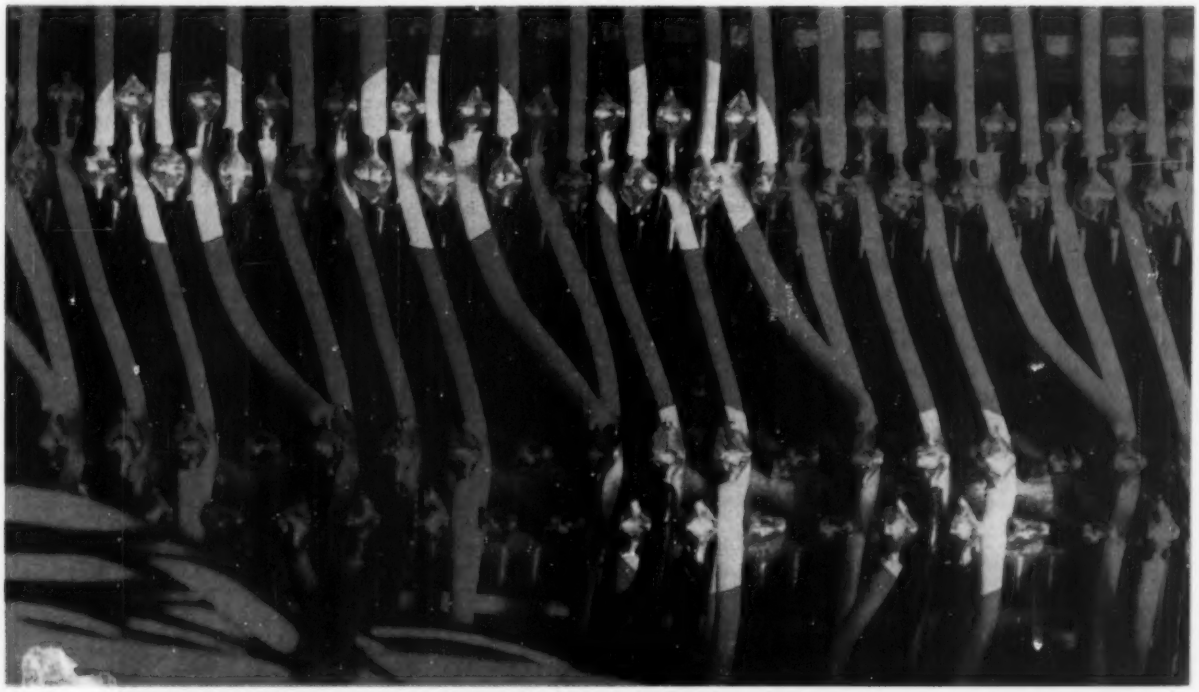
**Dielectric coolants** The extreme long life and thermal stability of G-E silicone fluids make them ideal as heat transfer media. Fluids of the SF-97 series can be pumped over a wide temperature range and will last indefinitely at 300°F in the presence of air, and more than 500 hours at 570°F in the absence of air. Further benefits include low volatility, chemical inertness, resistance to oxidation, and high dielectric strength.

**Compressible fluids** This liquid spring, which
lizes the compressibility of G-E silicone flu
can do the same work as a conventional spr
five times as heavy. All G-E silicone fluids h
relatively constant viscosity over wide temp
ture ranges, and high-temperature stability.
cosities range from 5 to 100,000 centistokes
25°C. Ideal for hydraulic fluids, fluid dri
dashpots, and dampers.

**The benefits of General Electric silicone fluids find uses in hundreds of products, from jet engines to suntan lotions. To learn more about these versatile, problem-solving fluids, write: General Electric Company, Silicone Products Dept., Section A647, Waterford, New York.**

GENERAL ELECTRIC

## how to design the . . .



# SOLDERED ELECTRICAL CONNECTION

Previously *(PE—June 13 '60* and *Mar 6 '61)* the author explained how to select the correct solder flux and choose among the 28 basic types of soft solders for mechanical and electrical applications. Now he concentrates on the knottiest problem of all—the electrical connection itself—and gives a complete design procedure covering all types.

**HOWARD H MANKO**
*Senior associate metallurgist*
*Product Development Laboratory*
*Data Systems Div, IBM, Poughkeepsie, NY*

When soldering is the method you decide to use for an electrical connection, you face a choice among 14 joint configurations and 10 basic solders. Penalty for a wrong choice is increased production cost, reworking and field service expense.

There is no shortcut in designing a soldered connection; choice is dictated by the reliable joint that will handle the current, is easily made, is mechanically strong, and has long life.

### DESIGNING THE SOLDERED JOINT

Soldered joint design is not simple; it involves flux chemistry, galvanic action, heat transfer, oxidation, mechanical stress, conductivity and process control. But these requirements can be met by a straightforward 10-point design procedure:

**Sketch the joint.** Usually the electrical and physical requirements dictate the approximate configuration, and a few simple sketches will pinpoint one of the 14 types.

**Check the process limitations.** Are the components or terminals made of special materials? Will pre-tinning or plating of components be necessary for protection or manufacturing reasons? Is there a temperature or thermal-shock limitation on any of them? Is a different

←CIRCLE 56 ON READER SERVICE CARD

**I—SOLDERED VS OTHER ELECTRICAL CONNECTORS**

**SOLDERING is probably your best method if your joining problem is:**

- **Simultaneous connection of multiple terminals on printed circuit boards or other uniformly shaped parts—one dip in a solder bath may do it.**
- **Complete metallurgical bonding but but easily reflowed for repair or change.**
- **Special configurations awkward to join by mechanical means, or too closely spaced for other methods.**
- **Flexible automatic assembly with low equipment investment.**

| Type of Bond → | Metallurgical | | | Mechanical | | | Chemical |
|---|---|---|---|---|---|---|---|
| | Solder | Braze | Weld | Crimp | Screw | Wrap | Conductive cement |
| Temperature limit of joint (melting or breakdown), °F | 100 to 800 | 800 to 1600 | conductor melting temp. | no limit except that of wire | | | 160 to 500 |
| Heating effect on assembly | small | large | small (quick) | none | | | cures at ambient to 250 F |
| Ease of rework and re-bonding of permanent joint | simple | | not practical | not practical | simple | | not practical |
| Size of joint, relative to conductor | small | | | medium | large | small | small |
| Process economy Equip. cost | low | medium | high | low | | | |
| Ease of automation | easiest | more difficult | more difficult | more difficult | | | |
| Extra hardware? | no | | | yes | | no | no |
| Joint stable? Vibration | yes | | | yes | no | yes | yes |
| Oxidation | yes | | | no | | yes | yes |

solder or flux needed for any individual terminal? It two terminals are close together, must they be separated with thermal barriers or protected by heat sinks during soldering? Must one terminal be made with higher temperature solder so that it won't melt when the second terminal is soldered? Does solder have a "pasty" range or does it go right from solid to liquid? Will the solder flux or the cleaning solution react chemically with the conductors, insulators or supports? Will intermetallics be formed? What about ease of automatic manufacture? Relative cost? All these limitations are discussed in detail in previous articles listed on page 64 and the worked-out electrical example in this article takes many such limitations into account.

**Pick conductor size.** Current-carrying capacity and mechanical strength are important. Table II lets you pick the right lead wire quickly.

**Select solder (or solders).** Table III gives the answers for all ordinary electrical applications. Where a pair of terminals requires two separate soldering techniques, work out the over-all sequence. If the surface needs a solderable coating (pre-tinning is one way), pick it with the help of Table IV.

**Look up resistivity ratio** of each solder vs the conductor in Table III.

**Calculate important joint dimensions** with the equations in Table V.

**Add a 50 to 100% safety factor** (depending on application) in addition to that inherent in the joint-dimension equations. Round off numbers to be consistent with a reasonable manufacturing tolerance.

**Design a trial joint**, complete with dimensions of lead wire and terminals, based on electrical requirements.

**Check trial joint** for mechanical strength by calculation or by building a prototype. Redesign if necessary.

**Make final engineering drawings** with specifications.

## HOW TO USE THE TABLES

The tables are arranged in the same step-by-step sequence as the 10-point design procedure. Table V ("Design Criteria") is the key table, and although it is not first in the sequence, it relates indirectly to every other table. For example, before you sketch the joint (first step in sequence) look at the typical joints in Table V.

**Current-carrying capacity** for copper wire (Table II) contains data recently calculated on a solid-state IBM 7090 data-processing system. Data are applicable to copper conductors at various operating temperatures, with conventional sleeve insulation. Normal ambient temperatures are assumed, with heat dissipated by natural convection and radiation.

**Properties of solders**—Table III lists only electrical solders, and the right one can be quickly selected. Resistivity ratio $\delta$ is ratio of solder resistivity to resistivity of

text continued, page 61

**II—CURRENT-CARRYING CAPACITY OF INSULATED ANNEALED COPPER WIRE**
**(Insulation Emissivity 0.9; ambient temp. 68F)**

| AWG (Wire size) | Solid Wire Dia, in. | Bare Stranded Wire: Over-All Dia, in. | Bare Stranded Wire: Strands/ Gage (AWG) | Insul. Wire Dia, in. | Current in amps to give these wire temperatures: 122 F (50 C) Solid | 122 F (50 C) Strand | 158 F (70 C) Solid | 158 F (70 C) Strand | 212 F (100 C) Solid | 212 F (100 C) Strand | Ultimate Tensile Strength, lb: Solid | Ultimate Tensile Strength, lb: Strand | AWG (Wire size) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6 | 0.1620 | 0.210 | 266/30 | 0.296 | 53.7 | 56.3 | 61.6 | 64.5 | 68.3 | 71.5 | 762 | 794 | 6 |
| 8 | 0.1258 | 0.167 | 168/30 | 0.224 | 39.6 | 41.6 | 45.5 | 47.8 | 50.5 | 53.0 | 480 | 499 | 8 |
| 10 | 0.1019 | 0.120 | 104/30 | 0.166 | 29.0 | 29.6 | 33.4 | 34.1 | 37.1 | 37.9 | 310 | 314 | 10 |
| 12 | 0.0808 | 0.096 | 65/30 | 0.146 | 21.8 | 22.1 | 25.0 | 25.4 | 27.8 | 28.2 | 197 | 198 | 12 |
| 14 | 0.0641 | 0.077 | 41/30 | 0.129 | 16.5 | 16.7 | 18.9 | 19.2 | 21.0 | 21.0 | 124 | 124 | 14 |
| 16 | 0.0508 | 0.060 | 26/30 | 0.115 | 12.5 | 12.6 | 14.4 | 14.4 | 15.9 | 16.0 | 78 | 79 | 16 |
| 18 | 0.0403 | 0.046 | 16/30 | 0.104 | 9.6 | 9.4 | 11.0 | 10.8 | 12.2 | 11.9 | 49 | 50 | 18 |
| 20 | 0.0320 | 0.038 | 10/30 | 0.055 | 6.9 | 7.2 | 7.9 | 8.2 | 8.8 | 9.1 | 31 | 31 | 20 |
| 22 | 0.0253 | 0.031 | 7/28 | 0.048 | 5.4 | 5.5 | 6.1 | 6.3 | 6.8 | 7.0 | 19 | 19 | 22 |
| 24 | 0.0201 | 0.024 | 7/32 | 0.044 | 4.2 | 4.3 | 4.8 | 4.9 | 5.3 | 5.4 | 13 | 13 | 24 |
| 26 | 0.0159 | 0.018 | 7/34 | 0.040 | 3.2 | 3.3 | 3.7 | 3.8 | 4.1 | 4.2 | 8 | 8 | 26 |

**III—PROPERTIES OF ELECTRICAL SOLDERS**
**(In order of increasing melting temp.)**

| Ref # | Alloy (%) | Typical names | Temperature, °F: Solidus | Temperature, °F: Liquidus | Resistivity, ρ: Solder, microhm/cm | Resistivity Ratio, $\delta = \frac{\rho \text{ solder}}{\rho \text{ conductor}}$ ρ: copper 1.73; brass 6.2; silver 1.59: Solder—Copper | Solder—Brass | Solder—Silver | Strength (of alloy alone), psi: Tensile | Strength (of alloy alone), psi: Shear | Approx $/lb (500-lb lots) | Application Tips |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 50 Sn-50 In | Indalloy #1; Cerroseal #35 | — | 243 | 14.7 | 8.5 | 2.4 | 9.3 | 1720 | 1630 | 18 | Low vapor pressure; good for metallized surfaces on glass |
| 2 | 19 Pb-30 Sn-50 In-1 Ag | IBM (special) | 251 | 268 | 12.5 | 7.2 | 2.0 | 7.9 | 2330 | — | 20.45 | Cryogenic (down to 4.2 Kelvin) |
| 3 | 63 Sn-37 Pb | Eutectic tin-lead | — | 361 | 15.0 | 8.7 | 2.4 | 9.4 | 7700 | 5400 | 0.8 | A common solder. No "pasty" range—goes directly from liquid to solid |
| 4 | 60 Sn-40 Pb | ASTM 60A | 361 | 370 | 15.0 | 8.7 | 2.4 | 9.4 | 7600 | 5600 | 0.8 | The most common electrical solder |
| 5 | 50 Sn-47 Pb-3 Sb | ASTM 50C | 365 | 399 | 18.0 | 10.4 | 2.9 | 11.3 | 8400 | 6850 | 0.7 | Resists creep well |
| 6 | 80 Sn-20 Bi | IBM (special) These are two recent examples of several dozen types developed by author | 289 | 400 | 21.0 | 12.1 | 3.4 | 13.2 | 10,500 | — | 1.82 | Thermal-emf-free joints for gold or silver conductors |
| 7 | 81 Sn-19 Bi | | 282 | 405 | 20.5 | 11.9 | 3.3 | 12.9 | 10,500 | — | 1.80 | Thermal-emf-free joints for copper or zinc |
| 8 | 96.5 Sn-3.5 Ag | Eutectic tin-silver | — | 430 | 12.3 | 7.1 | 2.0 | 7.7 | 2860 | — | 1.8 | High-temperature solder (for instruments) |
| 9 | 90 In-10 Ag | Indalloy #3 | — | 448 | 7.8 | 4.5 | 1.3 | 4.9 | 1650 | 1600 (joint) | 32.5 | For silver-fired glass and ceramics |

## IV—SOLDERABLE COATINGS ON ELECTRONIC COMPONENTS

| Surface Coatings | Corrosion Resistance | Storage Problems |
|---|---|---|
| **Silver** (solid or plated) | Good corrosion resistance in sulfide-free atmosphere | Pure humidity not detrimental. Slight sulfur contamination (combustion fumes, lubricants, cutting oils, organic matter, decay, etc) deteriorates surface rapidly |
| **Tin Lead** (hot-dipped or plated) | Sensitive to humidity | Keep surfaces at low humidity and room ambient. Elevated temperature might diffuse solder into base metal and deteriorate surface solderability |
| **Gold:** **Solid** | Very good corrosion resistance. | No storage problems |
| **Plated** (approx 0.0001 in.) or **flash** (approx 0.000,01 in. on silver) | Good corrosion resistance. Sensitive to humidity | Prolonged humidity speeds corrosion. (If gold is needed, assume environment will be poor, and protect accordingly) |
| **Cadmium** (plated) | Good corrosion resistance | Solderability decreases with humidity exposure |
| **Nickel-silver** (solid) | Good corrosion resistance | This alloy contains nickel, copper, zinc (no silver). Solderability degrades in high humidity because of the nickel |
| **Copper** (solid or plated) | Very sensitive to humidity | Common in printed circuits, before and after assembly. Very sensitive to corrosion |

## V—DESIGN CRITERIA FOR SOLDERED ELECTRICAL CONNECTIONS

**Nomenclature:**
- $D_1$ key conductor dia.
- $D_N$ solder fillet dia.
- $T$ thickness or side
- $L_f$ joint length
- $\delta$ resistivity ratio

| Type of joint | butt | | | lap | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | round-to-round | square-to-square | rect.-to-rect. | round-to-round | round-to-flat | flat-to-flat | wire-to-post | wire-to-cup | wire-to-hole |
| Mechanical security prior to soldering | none | | | | | | | very little | |
| Fixtures needed? | yes | | | yes | optional | | no | | optional |
| Solder cross-section area for calc. resistance | $\frac{\pi D_N^2}{4}$ | $\frac{\pi D_N^2}{4}$ | $W_1 T_N$ | $\frac{1}{2} D_1 L_f$ | $D_1 L_f$ | $W_1 L_f$ | $\frac{1}{2}\pi D_1 L_f$ | $\pi D_1 L_f + \frac{\pi D_1^2}{4}$ | $\pi D_1 L_f$ |
| Joint dimension needed for constant resistance | $D_N = D_1\sqrt{\delta}$ | $D_N = T_1\sqrt{\frac{4\delta}{\pi}}$ | $T_N = T_1\delta$ | $L_f = D_1\frac{\pi}{2}\delta$ | $L_f = D_1\frac{\pi}{4}\delta$ | $L_f = T_1\delta$ | $L_f = D_1\frac{1}{2}\delta$ | $L_f = D_1\frac{1}{4}(\delta-1)$ | $L_f = D_1\frac{1}{4}\delta$ |
| Electrical current capacity (relative) | small | | | large | | | medium | large | medium |
| Usage | not often used | | | often used | | | widely used | | |
| Ease of inspection | easy | | | easy | fair | | easy | difficult | fair |
| Special comments | difficult to make | | | | | | good for through wires | must bottom | fair for through wires |

key conductor. Table IV augments Table III by listing solderable coatings for the surface of a component.

### Joint design

Table V is a working guide to designing a soldered electrical connection, and in it you can insert the values read from the properties chart. Every common soldered electrical connection is covered here except printed circuit types, which are shown in Table VI.

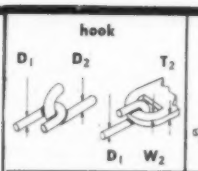
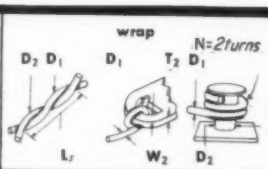
The table covers these three broad categories (based on degree of mechanical security prior to soldering): Not mechanically attached (butt and lap); partially attached (hook); and completely attached (wrapped).

Using the sketches and equations in the table, key dimensions of the joint can be calculated to ensure that the solder will not add any more resistance to the circuit than there would be if the copper conductor were continuous. This is important because local high resistance will raise the solder temperature, and perhaps weaken it.

None of the equations in the joint-design table is completely rigorous, and these simplifying assumptions—most of them are conservative—are made:

- Joined conductors have no direct mechanical contact—a layer of solder is always between them.
- Worst configuration (highest joint resistance) is assumed. For example, in the wire-to-cup joint, the wire is centered and not completely bottomed.
- The smaller (higher resistance) conductor is chosen as basic, and is given the subscript "1" in each equation. The resulting solder joint will match the higher resistance

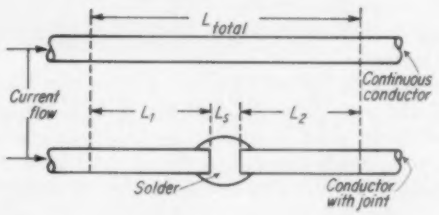
text continued, next page

| | hook | | wrap | | |
|---|---|---|---|---|---|
| |  | |  | | |
| | wire-to-wire | wire-to-flat | wire-to-wire | wire-to-flat | wire-to-post |
| | partial | | complete | | |
| | no | | | | |
| | $\frac{\pi}{2}D_1D_2$ | $D_1(2W_2+T_2)$ | $\frac{1}{2}D_1L_1$ | $D_1(2W_2+2T_2)$ | $D_1\pi D_2N$ |
| | $D_2=D_1\frac{1}{2}\delta$ | $D_1=\frac{(2W_2+T_2)}{4}\times\frac{4}{\pi\delta}$ | $L_1=D_1\frac{\pi}{2}\delta$ | $D_1=\frac{(2W_2+2T_2)}{4}\times\frac{4}{\pi\delta}$ | $D_2=D_1\frac{1}{4N}\delta$ |
| | medium | | large | medium | large |
| | seldom | very widely | often | widely | very widely |
| | easy | | | | |
| | good to connect strand to solid | specify solder top and bottom | good to wrap solid around strand | wrap 270 to 360 deg. or more | good for adjacent leads on same post |

## How to calculate solder-joint dimensions

■ Electrical resistance of a soldered joint depends on electrical resistivity of the solder, length of the current path (solder thickness between the joined conductors), and cross-section area of the solder measured perpendicular to current flow. Path length approaches zero in a good joint, but cross-section area must still be enough to handle the current in case path length is appreciable. Recommended relationship is this: solder area $\geq$ (conductor area) x (resistivity of solder)/(resistivity of copper).

The simple example of two round wires butt-soldered together (sketch below) helps explain how the equation is derived. These assumptions are made: all current must




be carried by the solder (no direct mechanical contact between conductors); thermal coefficient of resistivity (% resistance change per deg F) is nearly the same for conductors and solder, and solder does not heat up relative to copper; joint and rest of circuit are properly designed.

If there were no joint, conductor resistance $R_{total}$ would equal $\rho_c L/A_c$ where $\rho_c$ is resistivity of conductor, micro-ohms/cm (resistance of a piece 1 cm long and 1 sq cm in cross-section area); $L$ is total length of conductor; and $A_c$ is cross-section area ($\pi D^2/4$ for round wire).

Joint resistance (lower half of sketch) is $\rho_s L_s/A_s$, where $\rho_s$ is solder resistivity, $L_s$ is length of solder path between the conductors, and $A_s$ is cross-section area of solder. Resistivity of solder is ordinarily much higher than that for the conductor, so the solder "fillet" must be large in cross-section to keep over-all resistance low.

Over-all resistance of conductor plus joint is $R_1 + R_s + R_2$. This total value will be equal to or less than that for the conductor alone (upper half of sketch) if the joint cross-section area is larger than some critical value, depending on the resistivity ratio, $\delta = \rho_s/\rho_c$. In effect, $A_s$ must $\geq \delta A_c$. (For round wire, this is expressed as $D_s \geq D_c\sqrt{\delta}$.)

portion of the over-all circuit. (Using the larger conductor could give erroneous results if markedly larger.)

• Current-carrying cross-section of the solder (area perpendicular to current flow) is normally based on that wetted area of the smaller conductor adjacent to or projected on the larger conductor. The larger conductor might be wetted over a larger area, but this surplus is neglected in the equations. Interpretation of this rule is different for each class of joint, and inspection criteria cover all of them.

### Butted joints

Butted joints have conducting areas based on the end-area of the smaller conductor. Note that square-to-square joints have round-shaped solder beads, and rectangle-to-rectangle joints are "squared off."

### Lap, hook and wrap joints

Wetted area for a flat-to-flat joint is the facing area of the smaller conductor. A round conductor on a flat or grooved surface is wetted halfway around its circumference (a normal inspection requirement), but there are several ways to figure how much of this wetted area is effective in carrying current.

**Round-to-round lap** joint has an effective area based on only half the wire diameter (half the projected area) because the solder fillet is smaller in middle of the joint. If one wire is much larger than the other—3 to 4 x dia—then it should be treated as a round-to-flat lap connection.

**Round-to-flat lap** joint area is based on the projected area (dia x length) of the wire.

**Wire-to-post "stick"** joint (wire in a groove) area is based on wetted surface (half circumference of the wire).

**Wire-to-cup** and **wire-to-hole** joints are wetted over the entire wire circumference (in cup, bottom is wetted too) and all this area is effective.

**Hook-joint** conducting area is based on the projected area of the smaller conductor on the larger. (Hook must be at least a 180° bend.) Ignored in the equations is the small additional current path created by a secondary wrap-around effect, if any, of the larger conductor on the smaller.

**Round-to-round wrap** joint (twisted-wire pair) is similar to an untwisted round-to-round lap joint—effective area is half the diameter times the joint length.

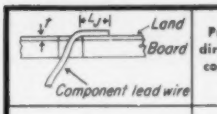
**Round-to-flat** and **round-to-post** wrap joints have an effective conducting area equal to wire dia x total length (projected area) where length is based on number of turns (N) and the post diameter.

In any type connection, extra-large fillets, beads, or other side-paths are not acceptable because they interfere with inspection of the joint.

### Design for easy inspection

There is no automatic way to inspect a soldered electrical joint: only visual examination will work. No excess solder is permitted—you should be able to see the outlines of the conductors under the solder. Good wetting (small angle of contact between solder and surface) is essential, and the solder surface should be smooth and shiny. The photos on the next page show examples of good and bad electrical joints.

**VI—TERMINAL LANDS FOR PRINTED-CIRCUIT BOARDS**

|  | Preferred direction for component lead | Solder fillet contour will be: | Remarks |
|---|---|---|---|
| teardrop | Toward long end | Even, and almost round | Good design. Enlarged contact area |
| round | Any | Even and round | The universal pattern |
| "D" | Toward tip | Uneven | Not widely used |
| rect. | Toward a corner or long end | Uneven | Not widely used |
| delta | Toward base | Uneven | Used if space very limited |

## PRINTED CIRCUIT CONNECTIONS

Printed circuit boards are ideally suited to soldered connections—single or multiple connections, manual or automatic techniques. Greatest asset is that all the solder joints on the board can be made simultaneously by dipping or wave-soldering.

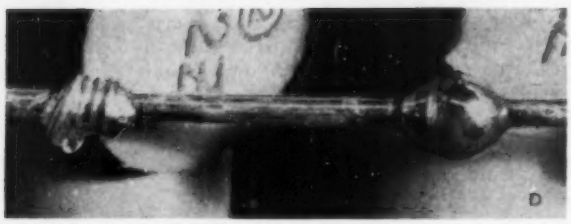
Component and conductor spacing must be wide enough to prevent "bridging" of the solder during this process, and the over-all pattern should suit the available automatic equipment. For instance, most automatic soldering baths have their greatest length in the direction of board movement; therefore, design the conductors and joints parallel to the long edge so that most of the lands are lined up in the dipping direction.

Terminal (land) on the board surface can have one of the five shapes in Table VI. The teardrop shape has two advantages: it is smaller than the equivalent round shape, and still has an even fillet. The component lead can be attached to the long end.

The best joint length for a component lead wire attached to the board can be calculated with the design equations on the previous pages, but normally length $L_J$ is made equal to $9t$, where $t$ is the conductor-land thickness. Electrical requirements will be met, and mechanical strength will be adequate. If mechanical failure does occur, it will usually be in the wire or component, especially for plated-through holes and inserted eyelets.

Thermal expansion can be a problem. Some board materials that have low expansion in X and Y direction, will expand in thickness as much as 1 mil during a solder dip (temperature rise of 400 F). If the board is double-sided with through-holes, special ductile copper plating (fluoborate) or prestressed eyelets may be necessary. Also, try to provide uniform "component population" (uniform heat capacity) throughout board to avoid hot spots or local heat sinks.

Capillary action—to help draw solder through the holes



**SOLDERED ELECTRICAL CONNECTIONS** must satisfy these requirements: adequate (but not excess) solder; visible conductor contours; and adequate (but not excess) joint length. Only 1 joint meets all the requirements: left-hand joint in (D). Unsuitable are: (A) has correctly attached wire but insufficient solder; upper and lower joints in (B) have more turns than needed (however, surplus turns in lower joint are for pre-assembly reasons); right-hand joints in (C) and (D) have excess solder that prevents inspection of the joint.

in the board—is necessary. Best results are with 0.003 to 0.005-in. clearance between lead wire and hole. Further help is derived from the dynamics of dip and "wave" soldering. If this operation is properly done, in some cases plating is not needed in the through hole: the solder will bridge the opposite faces of the board through the clearance.

### EXAMPLE OF JOINT DESIGN

**PROBLEM:** A thin film of fired silver on a glass component is to be connected to a cup terminal ¼ in. away, using uninsulated solid copper lead wire. Wire is to be soldered to the component first. Component is rated at 3½ amps at 160 F. A maximum of 6-lb pull on the

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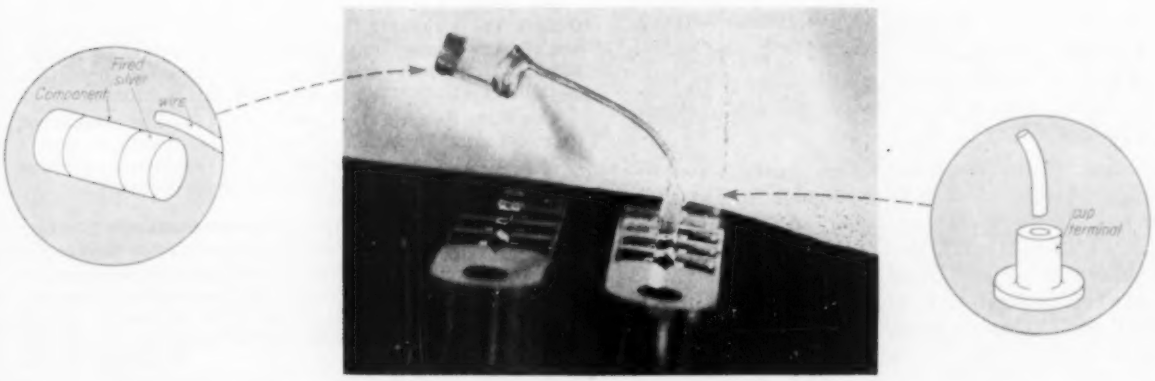


assembly is expected. Choose wire diameter, design both terminals, select the proper soldering alloys, suggest suitable soldering procedures.

**9-step solution:**

**1..Sketch the connection** (see below).

**2..Establish process limitations.**

Solder sequence: The short distance between the two joints calls for two solders with a large melting-point difference (similar to "piggy back" soldering). Otherwise heat will be conducted from one end of the wire to the other during the second soldering operation, and melt the solder from the first operation.

An alternate method is to clip a heat sink on the conductor between the terminals. However, the wire here is short and the heat sink would be in the way, perhaps robbing heat from the soldering area and slowing down the operation.

Thermal shock: Component is glass, and uniform preheating is advisable to permit the use of higher temperature soldering alloys.

**3..Pick conductor size.** Number 26 AWG solid wire has a current rating of 3.7 amps at 158 F. Tensile strength is 8 lb. Note: Table II is for insulated wire, but values for uninsulated wire will not differ much (answers will be conservative). No. 26 wire is 0.0159 in. diameter.

**4..Select the solder.**

For the ceramic: A thin fired-silver film on glass might be porous, or leave unwetted areas on the glass. Therefore use a soldering alloy able to wet glass. (Indium-containing alloys are reasonably suitable. They tend to penetrate through the porous silver, wetting the glass further.) See Table III for this final choice: 90 In–10 Ag (Ref # 9). It is expensive but has the needed special properties: good wetting, high melting temp, and 10% silver content which helps keep the fired silver from dissolving in the solder.

For the cup: 60 Sn–40 Pb (Ref # 4) is common and suitable. Melting temperature is 370 F. It can be soldered at a max temp less than the 448 F for the other terminal, and will not disturb it. A pre-tinned and solder-filled cup and a pre-tinned and pre-fluxed lead wire will ease assembly. Other tips: Heat the cup no higher than 450 F, and insert the wire into the molten solder, making sure it bottoms. Then remove the heat source. (A preset resistance-iron cycle or a thermally controlled iron will do the heating.)

**5..Look up resistivity ratio** (Table III). For 90 In–10 Ag, resistivity is 7.8 microhm/cm and $\delta = 4.5$ (with copper conductor). For 60 Sn–40 Pb, resistivity is 15.0 and $\delta = 8.75$.

**6..Calculate joint dimensions.** Two equations control the design: For the silver surface (round-to-flat lap connection), $L_J = (\pi/4)\ \delta D_1 = (\pi/4)\ 4.5 \times 0.0159 = 0.056$ in. (Note: $(D_1/D_2) < 1/4$, therefore use round-to-flat rather than round-to-round equation.)

For the cup terminal, $L_J = (1/4)(\delta - 1)\ D_1 = 0.032$ in. (Neither of these dimensions includes the safety factor.)

**7..Safety factor.** Add about 50% to area of contact. Thus, 0.056 becomes 0.080; and 0.032 becomes 0.050.

**8..Design the Joint.** For the fired-silver land: make it a band around the whole glass circumference (assumes the axial width is smaller than the calculated joint length. The wire can be soldered around the circumference.)

For the cup: ID should be 3 to 5 mils larger than the wire size. Total length of the wire is $\frac{1}{4}$ in. + 0.08 + 0.05 = 0.38 in.

**9..Check mechanical strength.**

For the fired-silver joint: Assume forces are in shear (the normal case in this type of assembly). Then: shear force = unit stress × solder area, $A_s$. $A_s = L_J D_1 = 0.08 \times 0.0159$ = about 0.0013 sq in.; shear force is 6 lb (given); therefore shear stress is 6/0.0013 = 4610 psi, which far exceeds the 1600-psi limit for 90 In–10 Ag in the Table III. Therefore increase $L_J$ about three times—to $\frac{1}{4}$ in., giving a good electrical margin of safety. Wire length now becomes $\frac{1}{4} + \frac{1}{4} + 0.05 = 0.55$ in. Make sure land on component is adequate for $\frac{1}{4}$-in. joint length.

For the cup: Strength in shear is important again, and $A_s = 0.05 \times D_1 =$ about 0.0025 sq in. Stress is 6/0.0025 or 2400 psi—which is less than the 5600 psi allowed for 60 Sn–40 Pb solder. Cup dimensions therefore are okay.

**For REPRINT of above article, just check 610 on one of the Reader Service cards found in this issue.**

**EDITOR'S NOTE:** The electrical connection—how to choose it and apply it—has been a frequent topic in these pages. Here are a few past articles:

**Reliable Electrical Connections,** Feb 2 '59, p 54—An on-the-spot report of an Electronic Industries Association Reliability Symposium. Here, solder, crimp, weld and other connection techniques are aired.

**Choose the Right Electrical Connection,** Dec 7 '59, p 71—Comprehensive survey of all known permanent and separable electrical connections with an easy-to-use selection table based on performance. There are sketches and data on 18 permanent and 13 separable types.

Soldered joints and connections have been given special treatment by the author of this article in his previous two articles:

**The Right Soft Solder,** Mar 6 '61, p 39—28 different solders are compared, and all important design criteria are discussed: matching solder to base metal; corrosion; strength; thermal expansion; electromotive potential; metallurgy intermetallics; and soldering techniques.

**The Right Solder Flux,** June 13 '60, p 43—The mechanism of solder-joint formation is described in detail, so that a joint can be properly engineered and evaluated. Covered are general fluxes, special electrical-joint fluxes.

A common use for solders is in automatic manufacture of printed circuits. Here is a recent roundup on that topic:

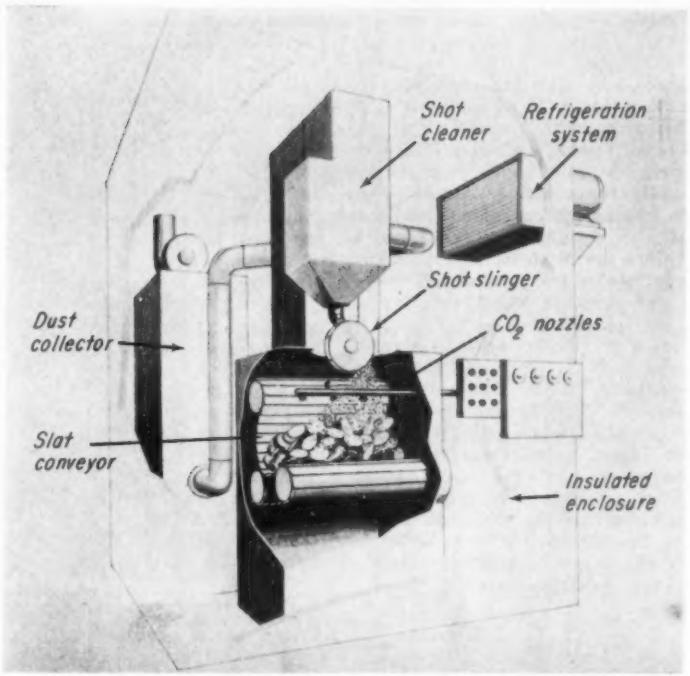
**Printed Circuits,** April 3 '61, p 42—Military requirements are explained and put in terms of industrial requirements. This comprehensive article covers all phases of printed circuitry from board laminations to component mounting.

—Frank Yeaple

# Controlled freezing trims molded rubber

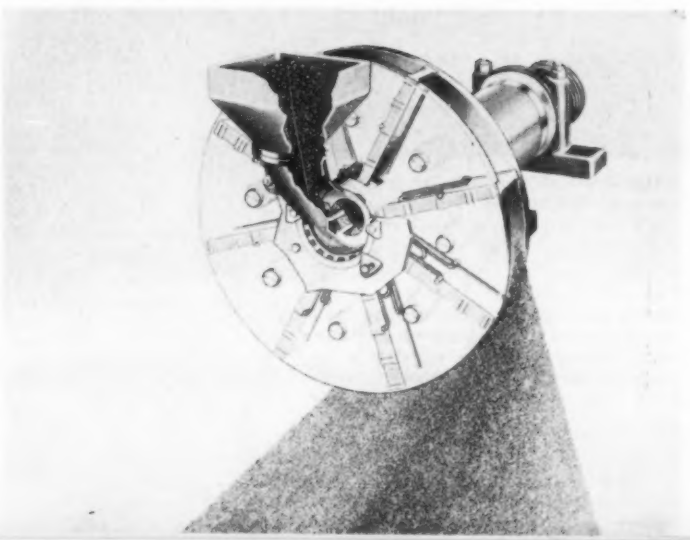
Flash is frozen, then removed from the rubber parts by centrifugally slung shot. Tumbling the parts on a slat conveyor reduces cycle time.

**THE DEFLASHER** and a dust-collection unit, which cleans the shot particles, are housed in an insulated vapor-tight enclosure. An auxiliary refrigeration system keeps the enclosure at 0 to —10 F. In operation a 2-cu ft load is dumped into the work chamber, and liquid $CO_2$ is sprayed through nozzles to freeze the flash on the parts (not the parts themselves). The slat conveyor is started and shot is hurled against the parts, fracturing and removing the frozen flash without damage to the soft unfrozen parts. The conveyor keeps the load tumbling constantly so that all parts and all surfaces of each part are soon brought to the top of the mass.




**SHOT IS HURLED** by an 8-bladed wheel. It centrifugally slings the particles in a controlled pattern across the width of the deflashing chamber. When struck by shot, the frozen flash breaks away—without damage to the parts, which themselves remain soft.

The shot-slinger is fed through its center where a control-cage opening determines the point at which the particles will leave the wheel. On leaving, they are picked up by a blade of the rotating wheel. Centrifugal force slides the shot along the blade until it leaves the tip with sufficient velocity to fracture flash upon impact. The slinger handles 350 lb of shot per minute (approximately 1200 million particles with a nominal size of 0.011 in.).



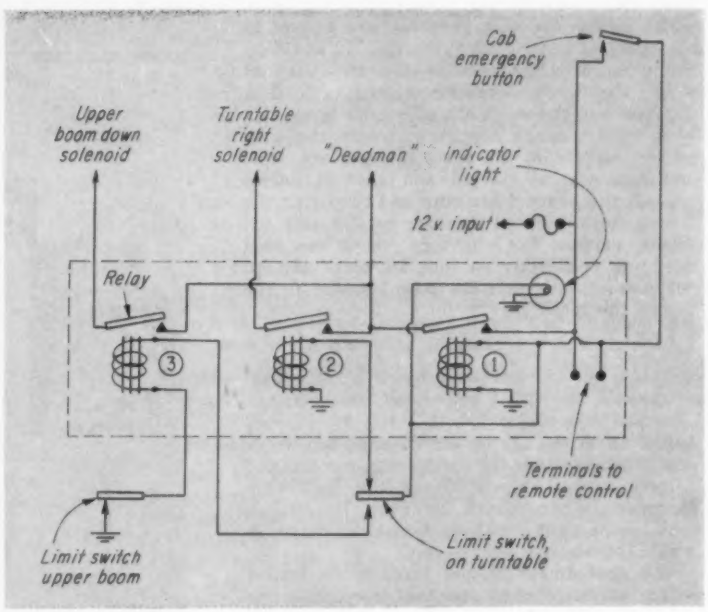
PS . . . The machine removes controlled flash that is not over 0.0025 in. thick from organic compounds and some silicones. Parts can be deflashed as long as flash thickness is 0.005 in. or less and wall of the part is at least 0.015 in. thick. Rubber Deflashing Machine is produced by Wheelbrator Corp, Mishawaka, Ind.

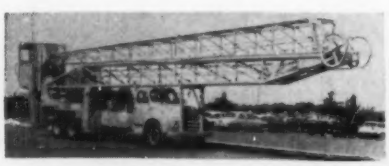
# It's a pushbutton to safety

Aerial tower is programmed to set an astronaut safely on ground in an emergency. Pressing single button in the rescue cab swings it to ground automatically.

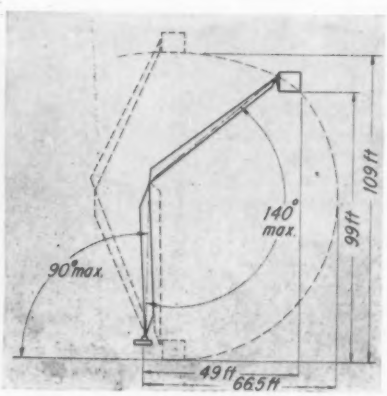
**HANDLING OF CAB** for normal operation is by three sets of pushbuttons which control solenoid-operated valves. These valves actuate hydraulic cylinders which move the upper and lower booms and rotate the mast. Safety switches with feeler extensions are mounted on the lower edge of the cab to prevent it from damaging the capsule or its booster. In addition, a deadman switch must be depressed before the platform may be moved. Duplicate controls on the ground can operate the tower and override platform controls.

In rescue operation, pressing the cab emergency button activates three relays. The deadman relay (1) bypasses this circuit to permit operation without the deadman button depressed. The turntable relay (2) actuates the "turntable right" solenoid to rotate the tower. The upper boom relay (3) actuates the "upper boom down" solenoid to lower the boom. Limit switches in the turntable and upper boom circuits halt the tower at the preselected position. No circuit is required for the lower boom, which is held stationary during emergency operation sequence.



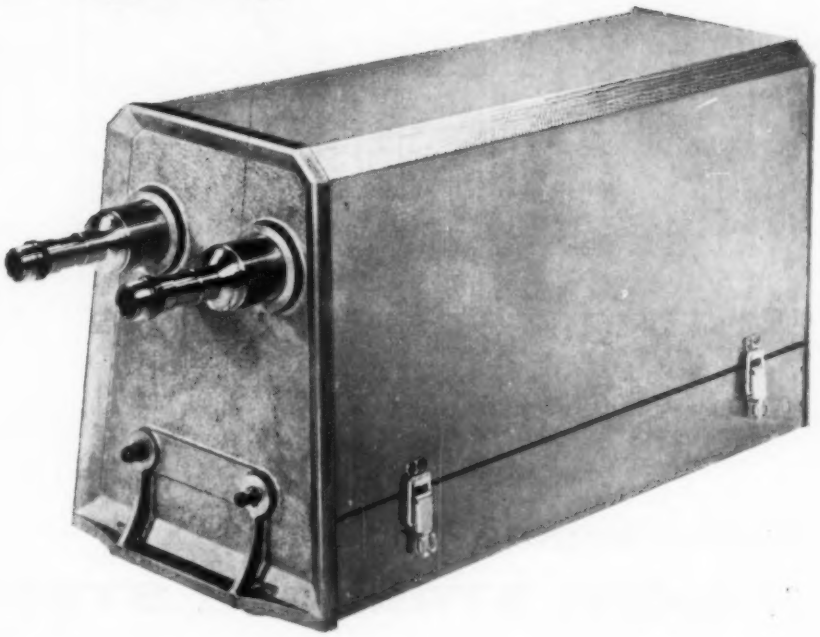
**TRUCK-MOUNTED BOOM** has max reach of 66.5 ft, can raise rescue cab 109 ft, and can traverse 180° while elevated. Outriggers on the truck provide a wider base for increased stability. The hydraulically operated tower booms incorporate a cable-connected parallel-arm linkage to keep the cab level. Hydraulic pumps are driven by truck engine through a power takeoff.

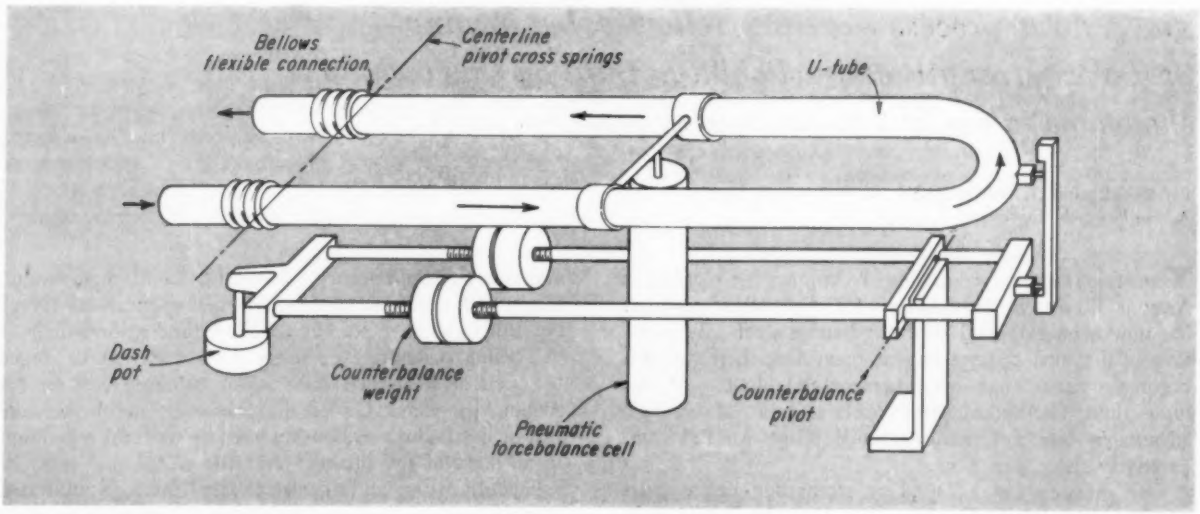



PS . . . Aerial tower is used in Project Mercury. After erection gantry is withdrawn, tower cab is positioned next to the capsule hatch until 1 minute before blast-off. Should an emergency arise during this period the astronaut can blow the capsule hatch away, climb into the cab, depress one button and be lowered to the ground. Hi-Ranger has a 6 x 8 ft enclosed cab that can support 1200 lb, is produced by Mobile Aerial Towers Inc, Fort Wayne, Ind.

# Measures specific gravity on the run

Instantaneous weighing of fixed volume of fluid is used to determine specific gravity of flowing liquid.

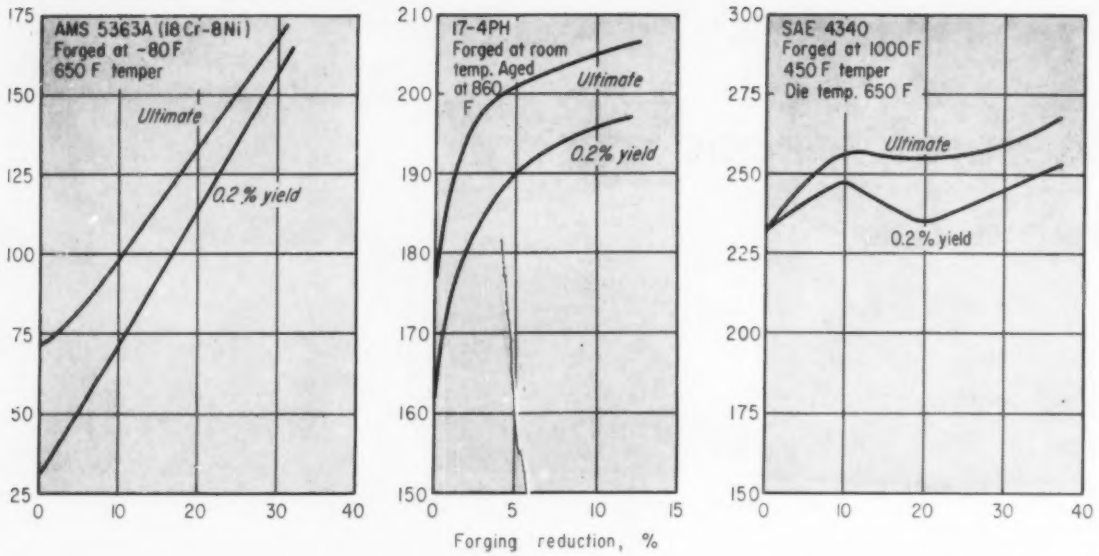





**DENSITOMETER WEIGHS** a fixed volume of fluid, at any given instant, with the pneumatic force-balance cell. The cell senses the moment of the U-tube about a cross-spring pivot whose centerline passes through the flexible bellows. To adjust the range of the output, the force-balance cell is moved toward the pivot to increase sensitivity (decrease range) and away from the pivot to decrease sensitivity (increase range). The cell used is a non-bleed null-seeking unit which requires only ± 0.001 deflection to produce the desired rate of response. Response may be increased by providing a small bleed. Tare weight of the U-tube as well as the effect of bellows is eliminated from the output signal by the adjustable counterbalance.

The cross-spring pivots and bellows cancel all pressure and flow forces. The adjustable pivots also permit the U-tube to flex with a minimum of hysteresis or lag in response.

PS . . . Densitometer is adjustable for a wide range of specific gravity measurements. Installed as a bypass, one unit can be used for several pipelines. Accuracy is within plus or minus 1% with fluid pressure up to 150 psi and temperature to 300 F. Actuating-air requirements are 0.1 cfm with air supply from 15 to 400 psi. The B-K Liquid Densitometer, portable and self-contained, is poduced by Bell Corp, Odessa, Tex.




**ALL THREE CAST STEELS** show improvement when press-forged. The AMS 5363, an 18 Cr–8 Ni stainless, gives best response—its yield strength is increased up to 600% and its ultimate strength up to 250%.

## press-forging for

# HIGHER STRENGTH STEEL CASTINGS

*The hybrid process—casting followed by forging—improves strength and reliability. Data on this technique show how to apply it to existing production parts.*

**J T BERRY and T WATMOUGH,** *research metallurgists*
*Armour Research Foundation*

The two-stage forged-casting technique, developed at Armour Research Foundation for light-alloy castings, has now been extended to strengthening steel. By press-forging the steel castings in semi-open dies, their strength becomes greater than by either method alone. At the same time, the hybrid process retains most of casting's advantages—low cost, nondirectional properties and comparatively short lead time.

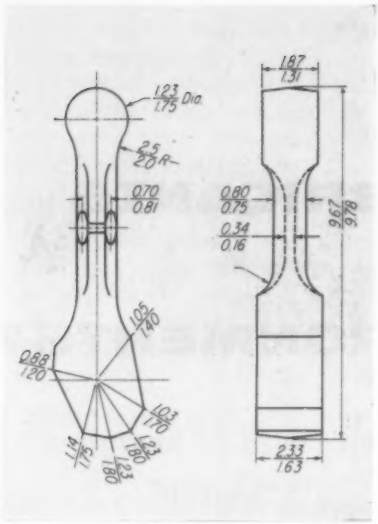
The pressing can be used to strengthen entire parts or can be limited to critical areas. Also, the hybrid technique extends the advantages of forgings to complex steel shapes: deep thin flanges can be cast, then pressed to the required dimensions.

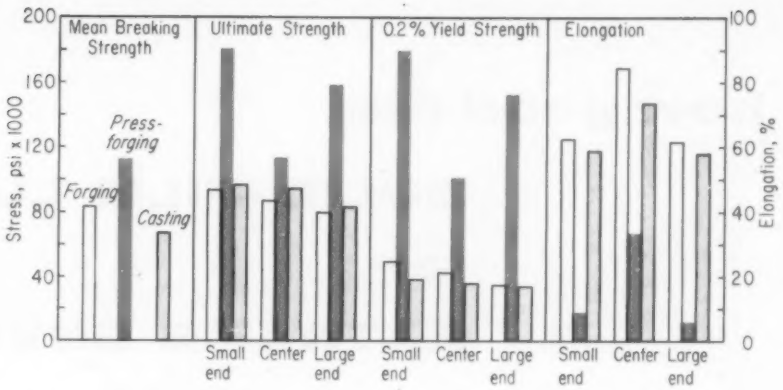
This article's ground rules for the process are based on data from a test program sponsored by Air Materiel Command's Manufacturing and Materials Technology Div. The program starts with forging-tests on cast bars and carries the working through to production parts.

Key to the low forging costs and short lead time is forging with dies that have been cast to shape. They are cast in graphite or silica molds bonded with bentonite clay and have sufficient accuracy as-cast for the forging contour. (Such cast dies also promise broader applications for all types of forgings, especially for short production runs.)

Tooling costs are even lower if the part can be forged by open or semi-open dies similar to those used in the Armour program. Closed dies, however, give better control of finished dimensions and ensure uniform reductions in all areas of the casting. But the closed dies must be sufficiently strong and massive to resist the high multiaxial stresses imposed during cold-pressing the steel. Some early attempts to press with as-cast closed dies failed because the dies were not strong enough. Closed-die forging for light-metal castings is easier because forging pressure is lower.

Basically, the process work-hardens cast metals by compressive deformations at temperatures under 1000 F; some materials respond best to subzero temperatures. This contrasts with the normal forging temperatures, above 2000 F, for wrought steels. Essentially, the method works the cast steel in one of two stages: at elevated temperature while it is still austenite (such as Ausforming); or near room




**CHOSEN FOR ARMOUR TESTS** was this production part, an engine-mount trunnion strut (AMS 5363). Sketch shows results of 30% reduction; in each pair of dimensions, upper value is as-cast, lower value is after forging. Bar charts show improvement in breaking strength of the strut and in tensile strength of specimens cut from the part.

temperature after the metal has been transformed into martensite (marten-forming).

### The cast alloys

Though the process is capable of working any low-carbon alloy steel, data presented here are limited to the following three steels in the test program.

**AMS 5363** has the largest gain in strength from working at subzero temperatures. Press-forging at −100 F (see charts) increases yield strength up to 600% and ultimate strength up to 250%. Ductility is reduced but final elongation (about 9% on test bars) is usually adequate.

This normally austenitic steel does not harden by heat treatment, but press-forging at subzero temperature transforms sufficient material to martensite to give the drastic improvements in strength. In general, the steels in this group with higher carbon (0.09%) show better strength improvement but also have less ductility than the steels with lower carbon (0.03%).

**The 17-4 PH** has increased mechanical strength with relatively small amounts of forging reduction. Forging at room temperature, where the structure is predominantly martensitic, gives 10% increase in both tensile ultimate and yield strength, with about 10% reduction. This increase in ultimate strength can be approached by press-forging at 450 F while the steel is austenitic, but resulting ductility is higher and yield strength is lower. Cold-working lowers the aging temperature for optimum combination of strength and ductility.

**SAE 4340**, a medium-carbon alloy steel, is difficult to forge because the metal transforms during working at temperatures of 1000 F, and at lower temperatures it cannot be forged because it is too brittle to work without cracking. There is some improvement in strength from forging at 1000 F, but similar increases can be obtained by modifying the heat treatment.

### An example

The production part shown here is a trunnion strut of AMS 5363 currently made by forging. Dimensions of the blank were modified to allow for change in shape during forging. In general, when a part is pressed, its height decreases, and length and width increase. Exterior radii become larger and interior fillets become smaller.

The sketch of the part gives dimensions for both the cast blank and after a 30% forging reduction. Although the web shows a reduction greater than this, the average reduction, including the flange, is 30%.

The accompanying bar graphs compare mechanical properties of full-size production parts made by casting, forging and the hybrid technique. Note that press-forging improved breaking strength of the part, as well as ultimate and yield strengths of test bars cut from three places on the part. Strength gain for the part was smaller than the increase obtained on the test bars.

The same production part in 17-4 PH also had mechanical-property improvements over castings and forgings. However, forged castings of this steel are notch-sensitive to minor defects at or near the surface. This makes the 17-4 PH difficult to work unless these casting defects can be removed by such processes as melting and casting under vacuum.

**EDITOR'S NOTE:** For more information on design techniques to ensure reliability in high-strength parts see:

**Quicker Diagrams Analyze Steel Fatigue,** Feb 13 '61, p 54—An often overlooked shortcut, this approximate diagram saves many hours of fatigue tests.

**New Magnetic Test Includes Stainless Steels,** Feb 6 '61 p 41—It shows up defects that older techniques miss—even in stainless steels that are normally nonmagnetic.

**The High-Strength Steels—What They Offer,** Jan 23 '61, p 54—Up-to-date comparison of other steels with newer compositions, and how to choose among these materials.

**Allowable Stresses in Flash-welded Joints,** Oct 31 '60, p 39—How to correlate fatigue data with magnetic inspection to determine practical stress values for design.

Also see our 64-p booklet—"Design with Steels." This comprehensive report includes 17 articles giving latest design data on a wide range of steels for high strength and high temperatures. Booklet is available for $2 from our Reader Service Dept, Product Engineering, 330 W 42 St, New York 36. —Herbert Kee

# how good are SOLID-FILM LUBRICANTS for EXTREME ENVIRONMENTS?

*Continuing research programs are aimed at finding a lubricant for 1000 to 2000 F and for high-vacuum service. Here are the results so far available.*

**B D McCONNELL**
*Fluids and Lubricants Branch*
*Nonmetallic Materials Lab*
*Materials Central*
*Aeronautical Systems Div*
*Wright-Patterson Air Force Base, Ohio*

Solid-film lubricants are now widely used in slow-sliding bearings operating under loads of 2000 to 80,000 psi with ambient temperatures of 450-500 F. Of course, greases and oils will operate satisfactorily under these conditions; however, the solid films offer a considerable advantage—lubrication for the life of the part.

A second possible advantage hinges on a solid film's hoped-for ability to operate in extreme temperature environments and under vacuum. There is considerable promise for such applications, as evidenced by the test results given in this article.

First, a quick review of current status. Commercially available solid-film lubricants are composed of a friction-reducing pigment; a bonding agent which is, in most cases, an organic adhesive; and a thinning solvent, to give the proper consistency for application. This mixture is applied by brushing, dipping or spraying to a metallic bearing surface which has been pretreated in some fashion to increase the adhesive bond between the metal and film. Of the above three methods of application, spraying is used almost exclusively because of the better control of uniformity in film thickness.

There are 10 or 12 major commercial vendors for these films. The relative merits of one film over those of another depend not only on the vendor to whom you're talking, but also on the pigments selected, the binders used, the ratio of the two to each other, etc. Many competing films are very similar in composition.

**The lubricating pigments** in these films are almost entirely graphite and molybdenum disulfide, Some films are composed of one or the other of these pigments, others contain a mixture of the two. For a mixture, the practice has been to use approximately 80 to 90% molybdenum disulfide and the remainder graphite. The contribution made by this small percentage of graphite has not been fully explained, but its effectiveness has been demonstrated in bench evaluation and service application.

**Bonding agents** consist primarily of organic resins and inorganic adhesives. Organic resins are of the phenolic and epoxy resin types. Epoxy compositions are preferred over the phenolic; however, mixtures of the two have sometimes been used. Organic resins won't work above 450 F; at this temperature thermal degradation begins and wear life falls off rapidly with increasing temperature.

Operating temperature of these films is extended with an inorganic binder such as a metal matrix composition or ceramic. The top temperature is primarily limited by oxidation of the pigment itself. Molybdenum disulfide suffers severe oxidation at temperatures above 750 F, while graphite is stable to approximately 1000 F but fails because of loss of absorbed water.

**Surface pretreatment** is almost as important as the film composition. For ferrous metals, the treatments include vapor and grit blasting, iron and manganese phosphating. Grit and vapor blast are purely mechanical working of the metal surface to create a roughened area. This allows the binder material more surface area contact, which increases adhesion.

Phosphate treatment shows greatest influence in increasing wear life, but is limited to metallic substrates of iron and steel. The phosphating procedure requires special care in application. Lack of rigid control of the bath conditions is believed to be one of the main reasons for the wide variance of wear life from batch to batch—sometimes even within a batch. Temperature must be controlled within 5 to 6 deg F of the optimum temperature to ensure proper crystal deposition.

Another deficiency in the phosphate pretreatment is its

temperature limitation. As shown in Fig 1, the cross-over point for phosphated and nonphosphated surface pretreatments is about 600 F. It appears, therefore, that since phosphating is unsatisfactory above 600 F, mechanical working of the surface as with grit or vapor blast will be needed, or a better high-temperature pretreatment developed for these temperatures.

### Speed and load vs wear

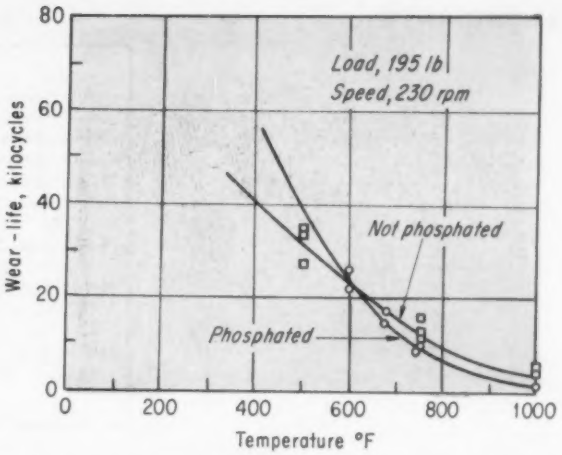
To determine effects of speed and load on wear life of films we used a tester with rub shoe and rotating test cup (Fig 2). Tests were conducted at a constant temperature of 250 F, representing a mean temperature between ambient and the upper limit for these films. There is a definite peak life at 120 fpm for either load.

### At 1000 F and beyond

In an effort to find a lubricant for over 1000 F a survey of over 22,000 compounds has been conducted by Midwest Research Inst under contract to this laboratory. This list was reduced to 16 films having the necessarily high melting point, hardness not greater than 4.0 on Moh's scale, good oxidation stability in air and reasonable friction characteristics.

To date the most promising film developed for operation at 1000 F is a lead sulphide (PbS) pigment bonded with boric oxide ($B_2O_3$). Wear life for this film is outstanding at 1000 F (Table I) but suffers at the lower temperatures where friction also goes up. Other tests indicate that the binder in such a composition is influencing lubricity and wear life much more than originally considered. Various other pigments were tried with $B_2O_3$, but the results were not as good as with PbS and in many cases the coefficient of friction and wear-rate were high.

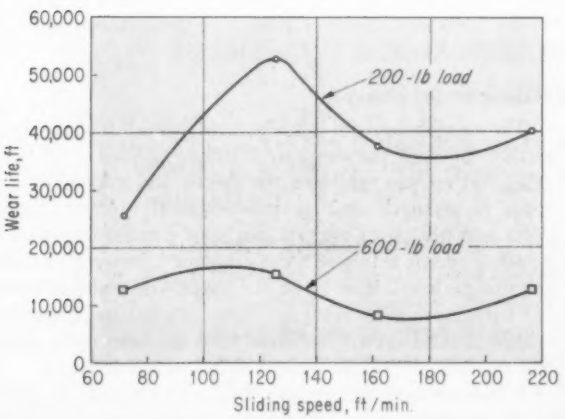
Performance of the PbS-$B_2O_3$ films at 1000 F has prompted the current effort to improve wear life at room temperature. Additions of graphite to the film produced very little improvement in the film performance at any



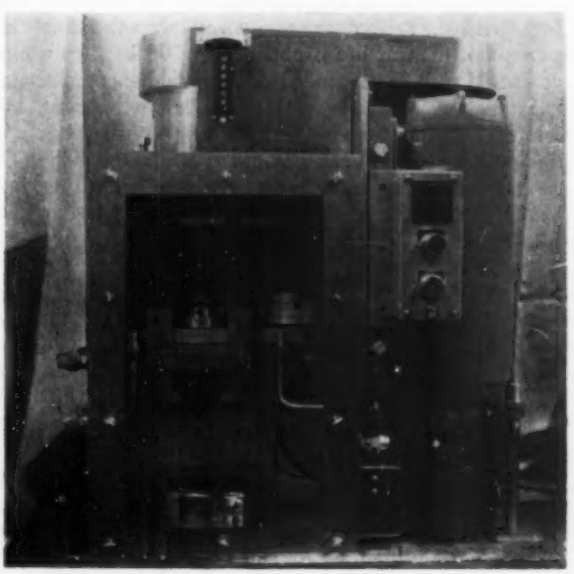

1..**SOLID-FILM LUBRICANT** is a commercially available metal-matrix bonded molybdenum disulphide. At room temperature, films on a phosphate-pretreated bearing have operated well over 100,000 cycles under same conditions.

**I—WEAR LIFE OF PbS FILMS BONDED WITH $B_2O_3$**

| L:B Ratio (by wt) | Temperature, ° F | Load, lb | Wear Life, revolutions | Coefficient of Friction |
|---|---|---|---|---|
| 6:1 | 1000 | 100 | 26,100 | 0.06–0.15 |
| 6:1 | 1000 | 100 | 35,000 | 0.12 |
| 15:1 | 1000 | 100 | 19,300 | 0.15 |
| 9:1 | 100 | 118 | 500 | 0.28 |
| 9:1 | 1000 | 100 | 47,600 | 0.08–0.14 |
| 9:1 | 100 | 100 | Failed on loading | ..... |
| 15:1 | 500 | 100 | Failed on loading | ..... |




2..**TWO RUB SHOES, DIAMETRICALLY OPPOSED,** characterize the Hohman A-6 tester. It can test at speeds from 50 to 800 rpm. The environmental test chamber permits temperature control to 1500 F, pressures above and below ambient as well as corrosive contaminants. Curves show wear life of resin-bonded films at 250 F.



II—WEAR LIFE OF Pbs-$MoS_2$ AND PbS-GRAPHITE FILMS

| Film Composition | L:B (by weight) | Temperature, °F | Load, lb | Wear Life, revolutions | Coefficient of Friction |
|---|---|---|---|---|---|
| PbS-Graphite-$B_2O_3$ | 7:1 | 1000 | 100 | 200 | 0.15–0.27 |
| PbS-Graphite-$B_2O_3$ | 7:1 | 100 | 100 | 1540 | 0.27 |
| PbS-Graphite-$B_2O_3$ | 7:1 | 750 | 100 | 340 | ..... |
| PbS-$MoS_2$-$B_2O_3$ (75%) (25%) | 8:1 | 120 | 100 | 100,000 | 0.03–0.06 |
| PbS-$MoS_2$-$B_2O_3$ (75%) (25%) | 8:1 | 1000 | 100 | 2500 | 0.11 |
| PbS-$MoS_2$-$B_2O_3$ (82%) (18%) | 11:1 | 1000 | 100 | 2000 | 0.04–0.18 |
| PbS-$MoS_2$-$B_2O_3$ (33%) (67%) | | 700 | 100 | 20,000 | |
| | | 1000 | 100 | 4000 | |

III—WEAR LIFE OF SOLID FILMS IN VACUUM

| Lubricant | Temperature, °F | Load, lb | Speed, rpm | Wear Life, revolutions | Coefficient of Friction | Pressure, mm Hg |
|---|---|---|---|---|---|---|
| Lub E | 150 | 120 | 100 | 25,600 | 0.05 | $5 \times 10^{-6}$ |
| Lub E | 150 | 215 | 100 | 240 | 0.04 | $3 \times 10^{-6}$ |
| Lub A | 150 | 215 | 100 | 540 | .... | $5 \times 10^{-6}$ |
| Lub A | 150 | 70 | 100 | 36,300 | 0.08 | $5 \times 10^{-6}$ |
| $M_7$ | 375 | 215 | 100 | 1,700 | 0.04 | $5 \times 10^{-6}$ |
| $M_7$ | 375 | 215 | 100 | 3,200 | 0.06 | $3 \times 10^{-6}$ |
| $MoS_2$-$B_2O_3$ (2:1) | 375 | 215 | 100 | 20,700 | 0.04 | $5 \times 10^{-6}$ |
| $MoS_2$-$B_2O_3$ (2:1) | 575 | 215 | 100 | 900 | .... | $8 \times 10^{-6}$ |
| $MoS_2$-$B_2O_3$ (2:1) | 760 | 215 | 100 | 700 | 0.04 | $1 \times 10^{-6}$ |
| PbS-$B_2O_3$ (6:1) | 760 | 120 | 100 | 800 | 000 | $1 \times 10^{-6}$ |

temperature (Table 2). Molybdenum disulphide gave an outstanding improvement in the wear life at room temperature but had a detrimental effect at high temperature. Best results to date have been films with a lubricant mixture of 67% $MoS_2$ and 33% PbS.

Effect of polishing and liquid-honing the races has also been studied. Preliminary results indicate substantial improvement in wear life is obtained at 700 F when a film of PbS-$MoS_2$-$B_2O_3$ is bonded on a liquid-honed substrate.

Precoating the races with $B_2O_3$ before applying the lubricant film had no significant effect on steel but was found to be essential for titanium races. Films of $MoS_2$-$B_2O_3$ on titanium failed upon loading with no precoating, but had an average life of 45,000 revolutions at room temperature with a $B_2O_3$ precoating.

### Vacuum properties

Four films with considerable wear-life data in air were chosen for the initial comparative wear-life studies in vacuum. Table 3 shows the test conditions and wear-life results. The first three lubricants show wear lives that are one-tenth their average values in air. These are graphite films and the drastic reduction in wear life of the film may be caused by the behavior of graphite in an atmosphere in which the partial pressure of water vapor is very low. The wear life of $MoS_2$ bonded with $B_2O_3$ is comparable to those obtained in air.

The three-component system of PbS, $MoS_2$ and $B_2O_3$ has been tested in vacuum. Various combinations were tested at 400, 700 and 1000 F. Films with the greatest ratio of either PbS or $MoS_2$ yielded low wear lives at all temperatures. The best wear-life results to date in vacuum ($10^{-8}$ mm Hg) were obtained with the film ratio of 13:13:2. It ran 2000 revolutions at 1000 F, 20,000 at 700 and over 200,000 at 400 F.

### Where we're going

The requirement for lubrication at 1000 F has now been pushed up into the range of 1500 to 2000 F. At these temperatures present substrate metals will approach their limit in strength and oxidative stability. Present solid films will no longer operate and new pigments as well as bonding agents will have to be developed. New exotic bearing materials will have to be developed and made compatible with lubricating systems. New concepts in lubrication will be derived. Perhaps the so-called dry lubrication methods will prove to be effective at these temperatures.

A vacuum wear-tester, very similar to the one described earlier, is now being constructed with temperature capabilities above 1500 F. Compounds with melting points and thermal stability above this temperature are being screened for possible lubricating pigments. New bonding techniques are being investigated. A program recently started at Southwest Research Institute is investigating lubrication and

bearing design for operation at 2000 F. Some of the compounds of beryllium, columbium, and other exotic metals are being investigated as possible bearing materials. Equipment has been designed to provide friction and wear studies at 2000 F.

**EDITOR'S NOTE:** For additional information on solid lubricants and other articles on wear and lubrication:

**Bonded Coatings Lubricate Metal Parts,** Sep 5 '60, p 48—Gives comparison chart and performance ratings of commercially available solid-film lubricants. Also includes recommendations for pretreatments, advantages and limitations of solid films.

**New Developments in Bearing and Gear Lubrication,** May 15 '61, p 98—New equations, design charts and performance data presented at 1961 annual ASLE meeting.

**Oil-mist Lubrication for Air Bearings,** Aug 29 '60, p 54—New technique prevents galling and seizure during starts and stops in step-bearings lubricated by air.

**Abrasive Contamination of Precision Mechanical Devices,** Aug 15 '60, p 51—Latest tests with polarized light show how abrasive machining can contaminate surfaces that must slide and roll together. Two cleaning procedures are given for solving the problem.

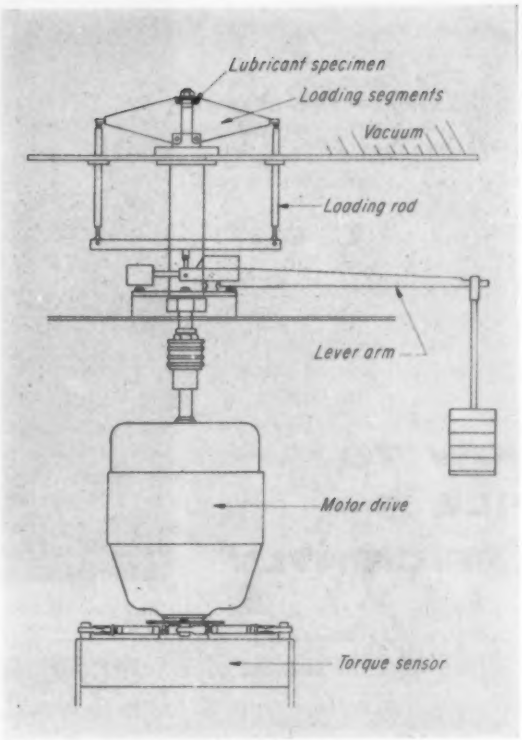
**Latest Design Requirements for Bearings and Lubricants,** May 23 '60, p 56—Staff report summarizes key design equations, charts, and concepts presented at 1960 annual ASLE meeting.

**How to Predict Wear Life of Rolling Surfaces,** May 9 '60, p 44—New load-stress K-factors for various material and hardness combinations simplify life-expectancy calculations for gears, cams, bearings, clutches and links.

**When to Specify Centralized Lubrication,** May 2 '60, p 56—Article presents 5 basic systems and gives 8 factors that determine whether these methods are preferable to point-to-point manual methods.

**Press-fit Test Picks Solid Lubricants for Extreme Pressures,** June 22 '59, p 64—A simple way to find the coefficient of friction when surfaces slide at high loads and low velocities.

—Richard M Koff




**3..VACUUM WEAR-TESTER** will operate at $10^{-5}$ mm Hg, test specimen temperatures up to 1000 F, loads to 80,000 psi and speeds to 200 fpm. Total revolutions are recorded by cam-operated microswitch. Torque is transmitted to a pair of symmetrically mounted proof rings. One ring has a differential transformer to detect strain. Signal is amplified and recorded directly in terms of frictional torque. Load is transmitted to rub shoes by two loading rods through O-ring seals.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# HOW TO FILE IT— EFFICIENTLY

*A filing system should give what you want when you need it, and save more time than it takes to run it. Here's a method for designing a system for any need, from a simple reminder to a library.*

**ROBERT W CARSON**
*Managing editor*

You take pride in your memory and make excuses for its failures—just as we all do. And because memory is fallible, we all use mechanical aids—filing systems to reinforce memory. But a common mistake in setting up a filing system is to ask it to replace memory. Then we end up spending more time than it's worth just in keeping the system working. The problem is to find the right filing system to provide the memory assistance needed with minimum effort, space and cost. Here is an orderly method.

For each filing problem determine: content, order, access time, and final disposition—in that sequence. Then follow the brief recommendations offered here when you select the record form, filing method and equipment.

**WHAT TO SPECIFY FOR A FILING DEVICE**

1. **Size of card or sheet**—depends on the amount of copy or number of items, and whether entries are typed or handwritten.
2. **Number of cards, sheets or catalogs**—both at the start, and maximum.
3. **Accessibility**—must contents of the file be fully or partly visible, or within easy reach; must items be removed readily from the file, or retained permanently?
4. **Frequency of use**—durability of equipment; justification for powered operation.
5. **Cost**—how much time will the file save; how much investment can be justified?

## Content

Is the information you want recorded a reminder, a current list, an index, an accumulative file, or a library?

**Reminder**—a temporary notation with no permanent value; to be discarded as soon as used. Examples: a visitor waiting to see you, a phone call to return, things to do today, a meeting or conference coming up, a letter to write, deadline on a regular or special report, a coming anniversary, an appointment for a future date, a convention or show to attend.

**Current list**—usually less than 25 items, often referred to and subject to frequent change. Examples: local telephone extensions or numbers frequently called, current active projects, members of a committee, list of projects in work.

**Index**—a record of a large number of items, more or less permanent, but arranged in some logical order to make each item easy to find: military specifications, drawings for a project, employes in the department, completed projects, abstracts of articles or papers.

**Cumulative file**—permanent, expandable collections of related items retained in some predetermined order but readily removed if necessary. Each item must be identified so it may be restored to its own unique place in the file. Example: copies of articles on a given topic, manufacturers catalogs, completed drawings on a current project, standard or stock components or materials, departmental instruction manual, photograph file, or minutes of a committee.

**Library**—collection of bound volumes of related items with a table of contents and an index for each volume: final reports on completed projects, tables of design constants, standard design procedures.

The first step then is to identify the content that is to be filed. Only then are you ready to take the second step—to establish the order.

### Order

Arrangement of items in a file may be random, by calendar, alphabetical or numerical. Selection of the order is governed by the character of the content and the number of items.

**Random**—the best method when the number of items is under 25 and the content of the file is subject to frequent change.

**Calendar**—by day of week, month, month and date, or year. This order is obviously selected when entries are placed in the file, or material is drawn from the file, in calendar sequence.

**Alphabetical**—the most flexible method, and capable of expansion or contraction without rearrangement of content. The standard 25-division alphabetical guide is good only for small collections (no more than 100 to 200 items, with random order within each alphabetical section). When the number of items in a single section exceeds 6 to 10, the group itself should be alphabetized. Add dividers or intermediate guides when the number in a single alphabetical group exceeds 20 or 30 items.

**Numerical**—may be your own "secret" code, the Dewey decimal system, the Library of Congress subject file, or something in between. A numerical system will invariably require a supplementary index which must be in a form easily changed. While attractive because of flexibility and unlimited degree of expansion, such a system can easily develop into a monster that consumes so much time there is none left for using the file.

### Access time

This is the one point where most "master" filing systems fail. If the file is to serve as a time-saving memory aid—and not merely as a monument to the file creator's ingenuity—the access time must be established for each file before it is set up. Three considerations are involved: how often will you (1) refer to the file, (2) insert new material, and (3) clean it out.

If the file must be referred to frequently, and therefore must be placed within easy reach and used with one hand, it unavoidably will occupy premium space on or in your desk. Better reconsider the content and order to see if you should trade off some size and space to gain faster access.

If use is infrequent, determine how long you can wait for an answer—a minute, an hour, or a day. Decide it now and let this decision help determine the location.

Must new material be inserted frequently and instantly? Or can additions be accumulated and made by someone else at less frequent intervals. Some trade-off with filing order may be required if frequent instant insertion is essential.

### Disposition

Before any file is started, a decision should be made—and recorded in the file—on the procedure for cleaning it out. A random file, for example, will quickly get out of hand unless you throw out as much as you put in. On the other hand, if the filed material is ageless in value (and little is) there is no point in starting the file at all unless space is available to store all the material that will eventually go into it.

### Filing devices

We have said nothing yet about record forms or equipment for the simple reason that this orderly approach to a file problem will write the specifications for the form and the filing device (see box). Any good office-supply store can then draw from stock the devices or equipment needed.

Reminders include an attractive array of novelties—from small magnets holding memos to steel partitions, to formed wire gadgets, "conversation pieces," or just scraps of paper in your shirt pocket or stuck to your desk shelf with adhesive tape.

Random lists can be a small 3 x 5 card file, perforated slips in a pocket notebook, or a typewritten sheet replaced as often as changes accumulate. Major problem is to keep the investment in preparation time to a minimum.

Index devices will range from a small 3 x 5 card file to a row of filing cabinets containing a million punch cards. Major considerations will be the number of items, the order and access time. The problem here is the tendency to get so involved in the machinery of the filing system that we end up buying equipment requiring unnecessary labor for maintenance of the file.

Cumulative file devices are also available in a great variety, some quite ingenious. Again, it takes a hard-headed approach to be sure that the selected system is adaptable to the filing order needed, but involves minimum labor for locating entries, inserting and removing items. It takes extra labor to punch holes, and holes may require reinforcement for frequently used sheets.

A plain, open file-folder permits insertions any place, but invites unrecorded removal. An alphabetical file requires thoughtful consideration of the total number of file guides needed to keep the number of items behind each guide within practical limits—not more than 20 to 30—or too much time will be lost in finding or replacing any one piece.

Permanent or semipermanent binders are also available in a profusion of forms. First, determine the level of permanence needed; then, the maximum page size, number of pages and durability needed. Some of these binders run into considerable expense; you may want to trade off some permanence for lower cost. Or if only some pages will be used frequently, protect them with plastic covers or have the pages laminated. And watch the weight of binders that must be used frequently; a light-metal back may be a better answer than a heavy fabric or plastic-coated board.

**EDITOR'S NOTE: These earlier articles offer systems for cumulative files that avoid alphabetical arrangement of material.**

**Indexing Device Solves Filing Problems, June 16 '61, p 48—Sight-through holes in home-made punch cards offer a desktop version of a library retrieval system good for 40,000 documents.**

**A System for Your Personal File, Apr 6 '59, p 43—An indexing aid for a special numerical system for filing 1000 or more catalogs.**

# how to listen... and remember

1..THREE SIMPLE STEPS...AND WHY TO TAKE THEM

**2..TEN WAYS TO BE A BAD LISTENER**

3..NOTE-TAKING...HOW AND WHY

■ Your mind, working at tremendous speed, can absorb thoughts at four or five times the rate at which a speaker delivers them. Unless you keep control, you'll hear only part of what's said, and retain only part of that. Here are 10 bad habits of poor listeners, according to Dr Ralph Nichols of the University of Minnesota.

1. **Calling the subject uninteresting.** You think "This guy has a dull topic"—and your mind takes off on one of the mental tangents it has stored up to use when you're bored. Said G. K. Chesterton: "In all this world, there is no such thing as an uninteresting subject. There are only uninterested people." Set your mind at the problem of why the subject is uninteresting. Is it because you don't want to know about it? Because you think you know more than the speaker?

2. **Criticizing the delivery.** "What a lousy speaker. That's 13 'Ah's' in 10 minutes." And again your mind takes off. From your standpoint you're wasting your time. But you can't leave anyway, so try to fight past the delivery to the message. Make use of your time. "What can't be cured must be endured"—so endure profitably.

3. **Becoming overstimulated.** You disagree with the speaker and plan what you'll say in rebuttal, or, more likely, what you'll tell your wife about him. Hear the man out before you judge him; "withhold evaluation until comprehension is complete," as one college puts it. Don't become so excited over one point that you fail to follow.

4. **Listening only for facts.** Facts can only support a theme, or main idea. The facts are unimportant unless you get the message. This is the most common of bad habits among listeners, because it deludes you into thinking you have learned something. Hunt for the gist, the generalization.

5. **Outlining everything.** Bad listeners assume that note-taking and outlining are synonymous: good listeners know they're not. The good listener makes little abstracts of ideas, annotates a text or outline. A good trick is to put the speaker's facts on one sheet, principles on another, then combine them later. If there is nothing to combine, he was poor, you didn't listen—or both. Try various techniques of note-taking to find those that fit (see part 3).

6. **Faking attention.** You settle comfortably, put your chin in your hand, and *look* interested and intelligent. This is a common bad habit that deludes many speakers and teachers. You are *not* listening, just playing a part, while your mind is elsewhere. Real listening takes energy; your heart will beat faster, your body temperature will rise—and you'll be fatigued afterward, not just a little sleepy.

7. **Tolerating distractions.** The bird on the limb outside, the moth around the light, the feedback in the speaker system, the departing blonde—all these are excuses your mind seeks to keep from working, to keep you from listening. The next step is the distraction you create—the nail file, the timetable, the doodling.

8. **Evading the difficult.** Never stretch your mind, if you want to be a bad listener. The bad listener wants no new experiences; he listens to the easy, recreational narrative. The good listener hunts for the tough, technical expository talks—and trains himself *while* he picks up information.

9. **Submitting to emotional words.** Don't let your personal and subjective thoughts deflect you. Such words as "automation," "income tax," "Truman" or "Roosevelt" neutralize some listeners—they get so mad they forget to listen. Others react to derogatory words affecting their personal lives: "mother-in-law," "Red," "landlord," "janitor," "clerk." It's the speaker's fault, but the listener's loss.

10. **Wasting thought power.** This is the constant, basic danger. You think at perhaps 400 to 700 words a minute, the speaker talks at 125, slows to 100 for emphasis. So three-fourths of your thinking capacity can be elsewhere. If it is, the other quarter will go with it. Net result: no recollection.

These 10 points have an obvious message for speakers as well. Watch out for them when you're doing the talking, and the way to make sure you will is to practice them when you're listening.

Basically, there are two kinds of listening, **casual** and **active.** The first is good enough for friendly chit-chat; your mind can wander widely during conversation and you can still keep track of the direction; usual development pace is slow. But beware of listening casually to a lecture, a speech, or the boss' remarks. They may sound casual, but are likely not to be. Cultivate, for these occasions, a desire to listen, an open mind, an ability to concentrate. Then you'll be alert to the essential ideas and the related ideas that round them out. And you'd better take notes. One of the hardest jobs is to convince yourself to make notes because your mind will insist, "I'll remember." Then it lets you down. ■

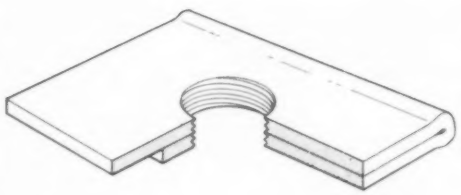
**Next week: Note taking—how and why.**

**Editor's Note:** This series, when completed, will be available as a free reprint. Simply circle 608 on the Reader's Service Card in this issue to reserve a copy.

# FOR BETTER GRIP . . . LONGER HOLES IN SHEETMETAL

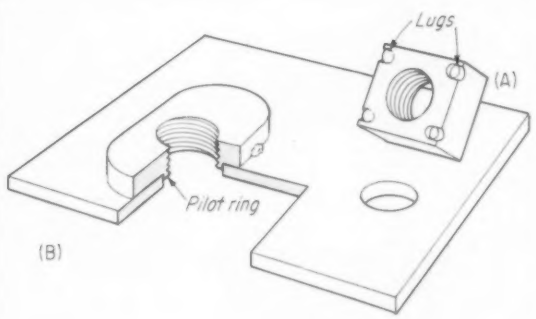
In steel or brass, depth of a threaded hole should be at least half its width, and in zinc or aluminum the right ratio is 2/3. If the metal is too thin, here's what to do.

**FEDERICO STRASSER,** *Mankowitz & Strasser, Santiago, Chile*



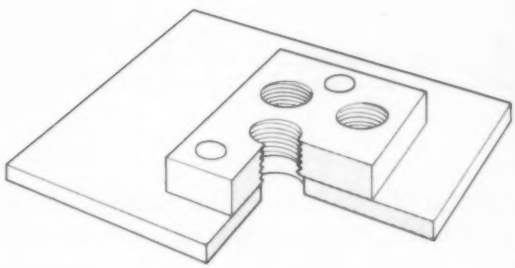
**1**

**BENT-OVER SHEET** doubles depth of holes near edge. Sometimes one more bend, for triple depth, is possible.



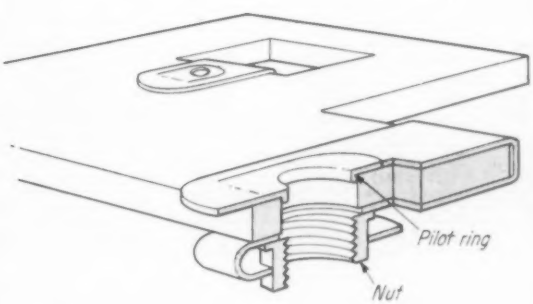

**2**

**PROJECTION-WELDING** fuses lugs on nut (A) to sheet. Flanged nut (B) for spotwelding has pilot rim to locate it on hole.



**3**

**PATCH OF SHEET** or plate, for a longer thread, serves holes away from edge; needs at least two rivets or welds to keep it from turning. Larger pieces cover group of holes.

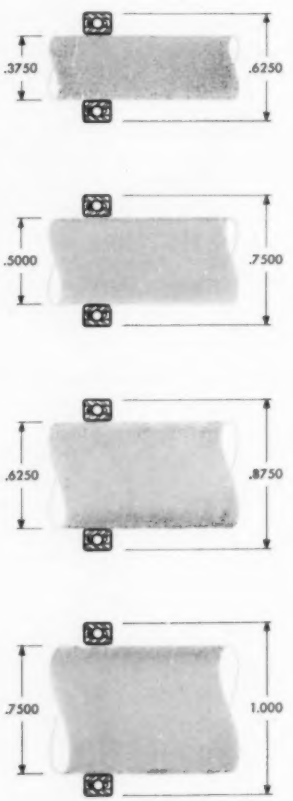



**4**

**CLIP** slips over edge of sheet, and positions on hole when pilot rim springs into place. Extra cutout next to hole allows installation away from edge.

continued on page 79

# NEW Instrument Bearings from NEW HAMPSHIRE Let You Beef Up The Shaft Without Increasing Bearing O.D.



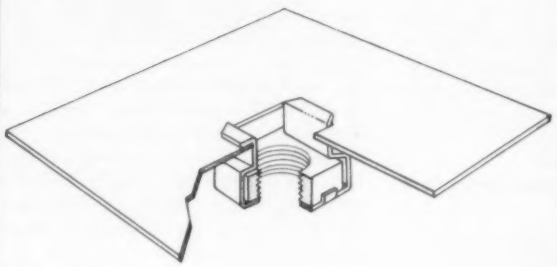

Here are four new opportunities to design shaft-to-housing relationships not possible with other bearings. As shown in the sketches, thinner bearing cross sections permit extra-large Bore-to-O.D. ratios.

This new series is manufactured to ABEC-5 precision standards or better, of stainless 440C steel, with plastic crown retainers which absorb lubrication.

| BORE +.0000 −.0002 | OUTSIDE DIAMETER +.0000 −.0002 | WIDTH +.000 −.001 | BEARING NUMBER | RADIUS | LAND DIAMETERS | | BALLS | | C RATING |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | INNER | OUTER | NO. | SIZE | |
| .3750 | .6250 | .1562 | SR620T | .010 | .457 | .542 | 12 | 1/16 | 81 |
| .5000 | .7500 | .1562 | SR824T | .010 | .587 | .672 | 16 | 1/16 | 95 |
| .6250 | .8750 | .1562 | SR1028T | .010 | .712 | .797 | 18 | 1/16 | 98 |
| .7500 | 1.0000 | .1562 | SR1232T | .010 | .837 | .922 | 22 | 1/16 | 108 |

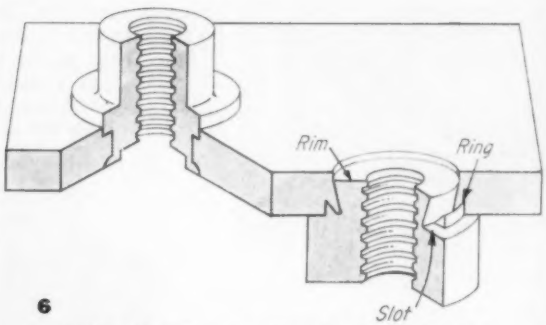
Write for full information or call in your New Hampshire Sales Engineer for application assistance.

**NEW HAMPSHIRE BALL BEARINGS, INC.**
**PETERBOROUGH, N. H.**



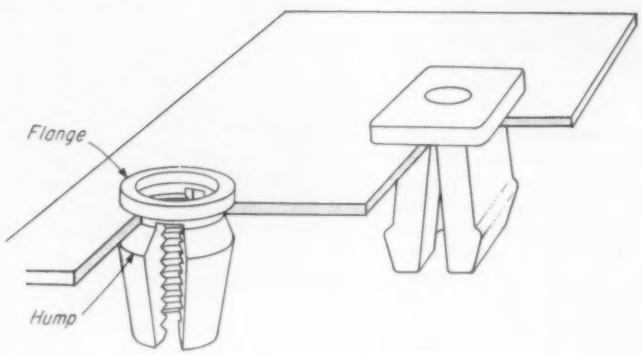
**5**

**FLOATING NUT** snaps into square hole and allows misalignment of bolt. If the thread strips, replacement is easy.




**6**

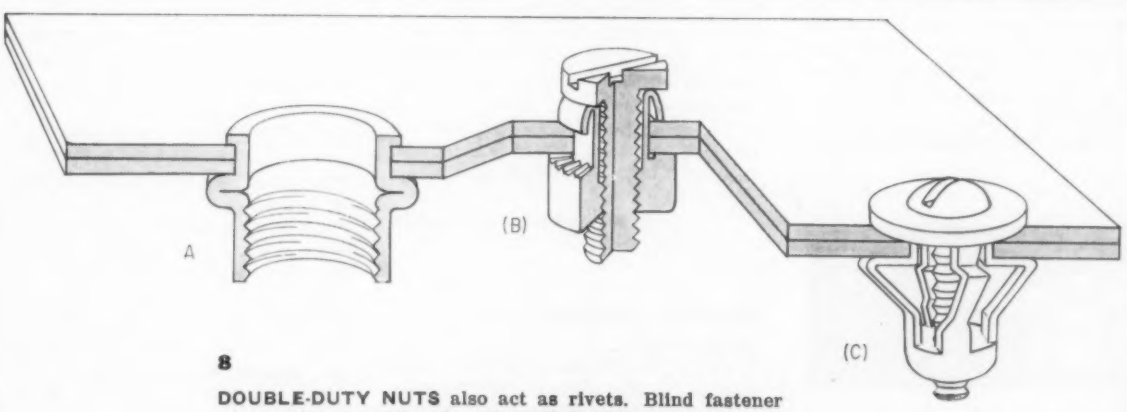
**STAKED NUT** fits in relieved hole. Relieving nut makes it easier to stake. Squeeze on clinch nut forces sheet to flow under tapered rim. Slots in ring keep nut from turning.




**7**

**TAPPED HOLE** snaps into sheet and grips it between flange and hump. Screw forces prongs apart so hump presses even harder on sheet. Slot digs into side of hole to prevent turning. Another version sits flush.

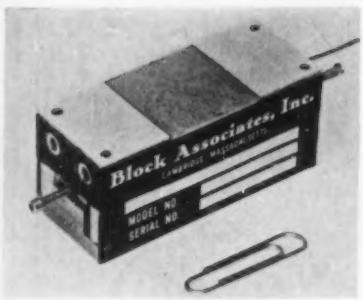
Square-shape plastic grommet, which doubles as insulator, cannot turn in square hole. Screw must make its own threads in smooth grooves, as it wedges grommet tightly in place.

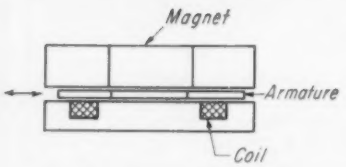



**8**

**DOUBLE-DUTY NUTS** also act as rivets. Blind fastener (A) requires special tools; other blind fastener (C) doesn't. Nut (B) bites into sheet when screw tightens down on neck, and bends it over.

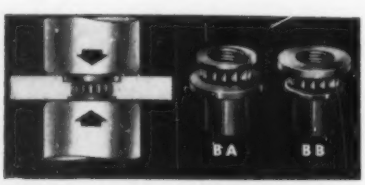
# SIGNIFICANT COMPONENTS MATERIALS, PROCESSES




**Push-pull linear actuator . . .** with a force of 3 lb—or 10 times larger in relation to size than that of equipment such as solenoids—provides response to command signals at least 10 times faster. Described as a biased moving iron magnet in which moving element is displaced perpendicularly to magnetic lines of forces. This permits a linear relation between force and both current and displacement. In addition to replacing solenoids, unit is suitable for applications such as: linear motions formerly obtained with a motor and an eccentric, high speed printing equipment, shaking tables, fatigue testing equipment, large displacement valves and vibration sorting equipment. Time constant is 5 millisec; stroke displacement, $\frac{5}{16}$ in.; max rated (linear range) stroke displacement, $\frac{1}{4}$ in.; and power requirement, approx 30 w. Priced at $55 with delivery in 5 wk. **Block Associates, 385 Putnam Ave, Cambridge, Mass.**

**Circle 300 on Reader Service Card**




**Flush-mounted fasteners . . .** made of alloy steel, are for installation into ductile material using standard punch-press procedures. Fastener is installed by pressing large flange into ductile sheet. Displaced material then forms into knurled undercut. Available in thread sizes from 2-56 through $\frac{1}{4}$-28 for sheet thickness of 0.040 to 0.180 in. Two self-locking styles and basic flush mounted fasteners are from stock; types AA and AB studs delivered in 2 wk. **Stake Fastener Co, 1710 Potrero St, South El Monte, Calif.**

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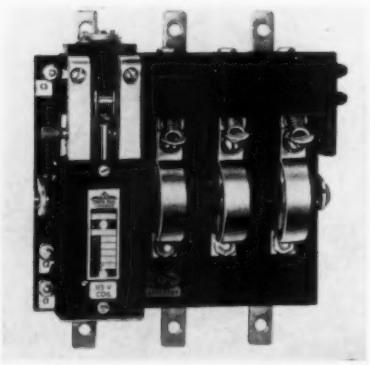


**Contactors mechanically held** in either open or closed position, eliminate hum usually encountered with electrically held contactors and are unaffected by line fluctuations. Low inrush currents allow wide flexibility in design of electrical systems. Control circuits can be longer; more contactors can be put on one line; and control devices will give longer service because they handle less inrush current. Molded epoxy coil is used for high resistance to moisture and insulation deterioration. Equipped with extended bus bars for installation in panels and switchboards. Available in 30-, 75- and 100-amp sizes and rated up to 600 v ac line voltage noninductive loads, max lighting loads of 277 v. Priced from $86 to $181, with delivery in 2 to 3 wk. **Zenith Electric Co, Dept PE-1, 152 W Walton St, Chicago 10.**

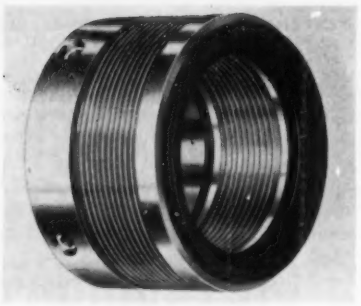
**Circle 302 on Reader Service Card**

**Phenolic molding compound . . .** is Orlon fiber-reinforced and is said to mold well in thin sections. Electrical properties include arc resistance of 131 sec; dielectric constant of 4.15 at 1 mc immersed in 73.4 F water for 24 hr; and dielectric strength, step by step of 318 v/mil immersed in 122 F water for 48 hr. Average physical characteristics are: tensile strength, 7000 psi; flexural strength, 10,000 psi; impact strength, 0.6 Izod, ft lb/in. notch; compressive strength, 32,000 psi; and heat distortion temp, 270 F. Supplied in nodular form, suitable for automatic preforming and molding equipment. Priced at 68¢ per lb in quantities of 1000 lb or over; 69½¢ per lb in 200 to 999-lb quantities; and 77¢ per lb in under 200-lb quantities. Delivery in 4 wk. **Rogers Corp, Rogers, Conn.**

**Circle 303 on Reader Service Card**

**Switch actuators . . .** allow "on" or "off" from 0° through 350° —job normally accomplished by using two 180° cams, back to back. In operation, a nylon wheel with deep and shallow notches engages switch roller. When front arm (two independently adjustable arms are mounted on motor shaft) engages a projecting pin on the nylon wheel, the wheel moves one station and detents with switch closed, remaining there until rear arm engages another pin on rear of wheel. This next movement indexes wheel 45° and detents with switch open. If arms are set back to back, switch will be closed on one revolution and open on alternate revolutions. One model uses heavy silver contact rated at 1500 w incandescent. When used at speeds between 1 and 60 rpm, life expectancy is over 100 million operations. Another model has snap switch for applications slower than 1 rpm or where DT switch is required. All micro switch ratings apply to latter, while actuator parts maintain life expectancy of former. Custom assembled with delivery within approx 24 hr. **Bayside Timers, 43-69 162nd St, Flushing 58, NY.**

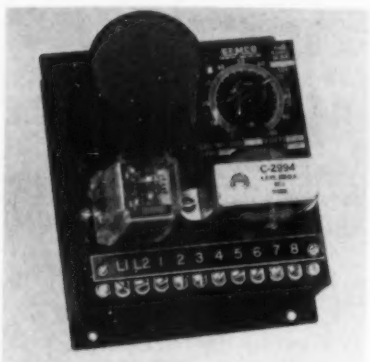
**Circle 304 on Reader Service Card**



## Rotating-bellows seal . . .

accommodates temperatures from —350 to 800 F; is automatically pressure-balanced without need of sleeves or special steps cut into shaft; and contains only one moving part. Heart of seal is a welded, stainless steel bellows attached to a drive collar at one end and a carbon retainer for the carbon seal ring at other end. Bellows core and its two welded fittings rotate as a single unit. Mating ring, against which carbon ring runs, is stationary. Accepts pressures to 300 psi. **Sealol Inc, Providence, RI.**

**Circle 305 on Reader Service Card**



## Magnetic timer . . .

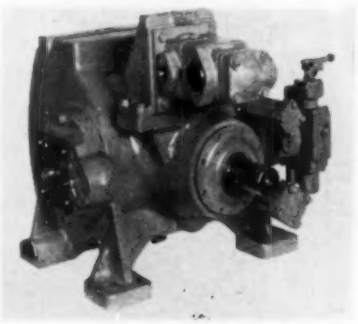
has a saturable circuit, eliminating vacuum tube failure and contains no moving parts except for output contacts. Available with time ranges from 0.1 sec min to 38 sec max. Provides repeat accuracy of ±1% of max time range with line voltage variation of ±15%. Reset time is only a few cycles of ac power supply, allowing close timing intervals. One type provides time delay after opening and another after closure of initiating switch. Output contacts consists of DPDT, two N.O. and two N.C. contacts rated at 5 amp, 115 v ac; 5 amp, 28 v dc. Standard models operate with 115-v, 60-c power supplies. **Gemco Electric Co, 25685 W Eight Mile, Detroit 40.**

**Circle 306 on Reader Service Card**

## Ratio between rotary speed . . .

of cylinders on paper, textile and similar wet machines is computed by electronic sensing system that counts number of rotations of each of two rolls and electronically computes ratio of these two quantities by a simple digital method. Ratio then is digitally multiplied by a single constant to simultaneously adjust speeds for actual, changing diameters of the two rolls. Answer, expressed in percentage, is displayed in illuminated numerals within ½ sec. Operates to 0.1% accuracy at all operating speeds and requires no calibration. One model has max capacity of 5 channels for measuring 5 draws or speeds; another handles as many as 50 draws or speeds. **Louis Allis Co, Dept P, 427 E Stewart St, Milwaukee 1.**

**Circle 307 on Reader Service Card**



## Piston pumps and motors . . .

are rated to 180 gpm and 5000 psi. Available as either pumps or motors with fixed or variable displacement. Pumps operate at 1200 rpm with atmospheric intake and at 1800 rpm with supercharging, permitting use of standard electric drive motors. Pump delivery at these speeds is 120 and 180 gpm, respectively. Max displacement is 23.7 cu in. per revolution and max torque is 378 lb-in. per 100 psi. With servo control, variable displacement pump can be stroked from max displacement in one direction to full opposite in about ½ sec. Variable package with control and auxiliary pump has hp-to-weight ratio of about 3.2 lb per hp, based on 1200 rpm and 5000 psi. **Vickers Inc, Div of Sperry Rand Corp, Detroit 32.**

**Circle 308 on Reader Service Card**

## Enameling steel . . .

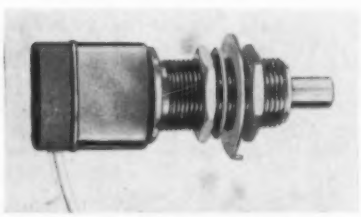
for one-coat, direct-on application, reportedly can cut enameling costs from 15 to 50%. Normal porcelain enameling requires two coats, one an undercoat of gray or black. Produced by an "open coil annealing process", the new sheet steel has ⅓ the carbon content (0.003%) of ordinary enameling iron and compares with this material in cost. Can be sharp-cornered or deep-drawn before enameling and resists fishscaling and boiling during enameling. Also can be worked into intricate shapes. Thickness of coat is only 3 to 4 mils, compared with 6 to 8 mils or over for two-coat methods. Suitable for luminescent panel construction, and for any appliance or cabinet where porcelain enamel is used. Available in sheet and coil in 14-26 gage thicknesses and widths to 60 in. (wider on special order). Priced at $6.775 per 100 lb. **Bethlehem Steel Co, Bethlehem, Penna.**

**Circle 309 on Reader Service Card**

## Heat-stable laminate . . .

is fiberglass-reinforced polyester flat sheet stock whose properties meet or exceed NEMA GPO-1 specifications. Said to retain 100% impact strength even after heat aging at 482 F and 75% perpendicular dielectric strength after 200 hr at 302 F. Can be punched or sheared cold without delamination, cracking or hole breakout and is suitable as electrical insulation or as wedges and top sticks in Class B rotating apparatus. Available in thicknesses of $\frac{1}{16}$ to $\frac{3}{8}$ in. in standard sheet sizes of 36 x 72 in. and 24 x 36 in. (heavy sheet stock in standard thicknesses of ¾ to 2 in. also available). The $\frac{1}{16}$- and $\frac{3}{32}$-in. thicknesses are priced at 65¢ per lb in quantities of 300 lb or more; ⅛- through $\frac{3}{8}$-in. thicknesses, 58¢ per lb. **Glastic Corp, 4321 Glenridge Rd, Cleveland 21.**

**Circle 310 on Reader Service Card**



## Plunger-type limit switch . . .

originally designed for aircraft use, is SPDT, hermetically-sealed unit with corrosion-resistant material throughout, three potted leads and sealed plunger. Operating force is 6.7 lb, ±2.2 lb; release force, 3.5 lb min; pretravel, $\frac{1}{16}$ in. max; overtravel, 0.250 in. min; weight, 0.125 lb. Rated at 5-amp resistive and 3-amp inductive at 28 v dc, 115 v ac. Min life expectancy is 25,000 cycles. Measures 2 x ¾ x ⅝ in. and is installed by two hex nuts adjustable along a $\frac{13}{32}$-in. threaded bushing. **Haydon Switch Inc, Waterbury 20, Conn.**

**Circle 311 on Reader Service Card**

## High-speed switching relay . . .

uses a pair of magnetically operated contacts mounted in a glass tube, hermetically sealed in a gaseous atmosphere. Capable of millisec switching time and 20,000 operations at ½ amp, 28 v dc or 100 million operations at ¼ amp, 28 v dc. Operates in temperatures from —67 to 302 F and withstands min vibration of 0.08 in. or

continued on page 82

# Design Uniform lift into equipment with DUFF-NORTON WORM GEAR JACKS

Many designers find a ready answer to precise control of linear motion in machinery or equipment with built-in Duff-Norton Worm Gear Jacks.

They are used singly, in tandem and in multiple jacking arrangements to position loads weighing from a few hundred pounds to as much as several hundred tons.

When connected in tandem or groups of four, six or more, these jacks always raise or lower in exact unison regardless of load distribution. They are also used for application of pressure, to push or pull and as linear actuators.

Duff-Norton Worm Gear Jacks are self-locking and will hold heavy loads in position indefinitely without any creep. Since there is no fluid or air to leak, the action is always positive and maintenance is no problem.

These jacks are available in eight standard models with capacities ranging from 2 to 100 tons and with standard raises from 6 to 24 inches. Special raises can also be furnished.

To learn more about how Duff-Norton Worm Gear Jacks may be used in your equipment, send for the bulletin which shows engineering drawings of jacks, Duff-Norton Mitre Gear Boxes and typical applications. Ask for AD 66DD.

**DUFF-NORTON COMPANY**

Four Gateway Center · Pittsburgh 22, Pa.

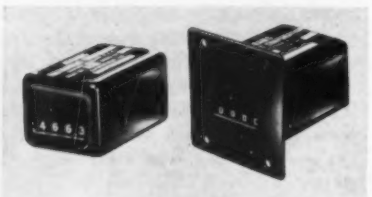
DUFF-NORTON JACKS
Ratchet • Screw
Hydraulic • Worm Gear

COFFING HOISTS
Ratchet Lever • Air
Hand Chain • Electric




20 g, 10 to 500 cps and shock of 40 g. Carries loads from 15 v-amp down to microamp. Contacts are SPST or SPDT, normally open or biased closed, or a combination of both. From stock at $3.50 each in quantities of 1 to 9. **Airpax Electronics Inc, Cambridge Div, Cambridge, Md.**

**Circle 312 on Reader Service Card**



### Miniature magnetic counter . . .

is vapor-sealed to operate in extreme moisture, humidity, salt spray, sand and dust. Adds and subtracts at 10 counts per sec max with a capacity of 0 to 9999. In operation, each time an electrical impulse is received, right-hand figure wheel advances ½ count. When impulse is removed, count is complete by means of a return spring drive. At each tenth impulse each figure wheel advances preceding wheel to left by one count. White figures are 0.120 to 0.130 in. high. Operating voltage is 20 to 29 v dc; power consumption, 8.5 w at 28 v dc; and operating temperature, —65 to 150 F. Weighs 5 oz max and has life expectancy of 1 million operations. **Abrams Instrument Corp, Lansing, Mich.**

**Circle 313 on Reader Service Card**

### Resistance force transducers

are solid-state, wafer-type units available in 0-0.5 to 0-5000 lb ratings. Change resistance from 500 to 26,000 ohm according to force ratings. Operate instruments, lamps, miniature motors, etc directly within watt rating and without need for amplification. Only power supply required is a flashlight cell or 1.6 v dc regulated. Current used is less than 5 milliamp for largest size and a few microamp in others. Higher voltage may be used with increase in resolution. Diameters range from 0.250 to 1 in.; prices from $18 to $42. **Clark Electronic Laboratories, Box 165, Palm Springs, Calif.**

**Circle 314 on Reader Service Card**

### 6-ply wire-reinforced hose . . .

withstands min burst pressure of 50,000 psi—said to be more than twice that of standard types of wire-braid hose. Under severe high pressure testing conditions, hose withstood pressure of 56,000 psi before bursting. Suitable for —40 to

continued on page 84

# NEW FAST DRAW TECHNIQUE CUTS FABRICATING COST OF MAGNESIUM

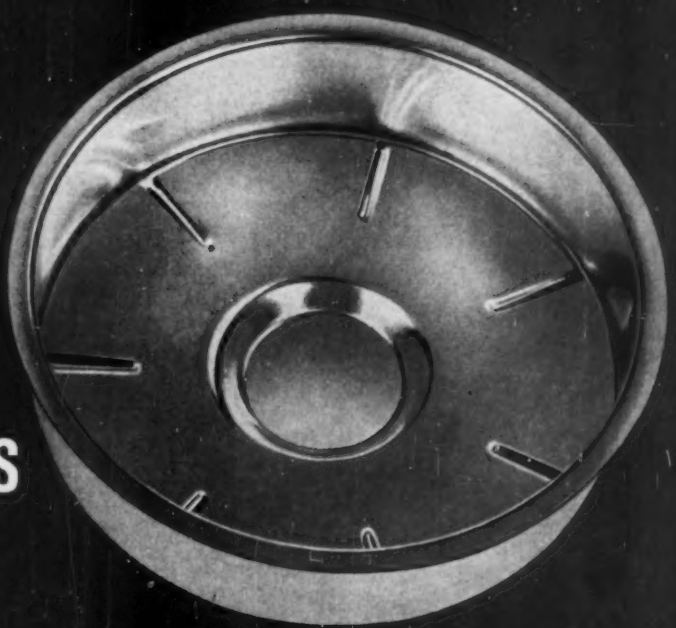
Magnesium parts are now being deep-drawn experimentally at high speeds with a newly-developed process. It uses standard mechanical presses, moderate temperatures (400°F.) and ordinary soap-type lubricants. The part illustrated below was drawn and ejected in 1½ seconds.

This technique cuts the cost of fabricating cylindrical parts of magnesium—with its unparalleled combination of light weight, stiffness and strength. Draws to a 50% reduction are made readily at normal production speeds with a minimum of die stages.

The new technique is expected to find use for many drawn magnesium parts, including components of appliances and business machines. Find out what it can do for you. Write THE DOW METAL PRODUCTS COMPANY, Midland, Mich., Merchandising Dept. 1109DZ6-12.

## FROM BLANK...

## TO PART...



## IN 1½ SECONDS CYCLE TIME

DOW **THE DOW METAL PRODUCTS COMPANY**

*Division of The Dow Chemical Company*

CIRCLE 83 ON READER SERVICE CARD

200-F service, it includes an oil-resistant Neoprene inner tube, covered by an open textile braid reinforcement. Interply friction layers cover 6 plies of spirally wrapped heavy wire (0.022 in. dia) reinforcement. Synthetic rubber outer cover resists sun, weather, oil and abrasions. Available from ⅜ to 1½ in. ID. **Anchor Coupling Co Inc, Dept PR-10, 342 N 4th St, Libertyville, Ill.**

**Circle 315 on Reader Service Card**

## Electrohydraulic servovalve

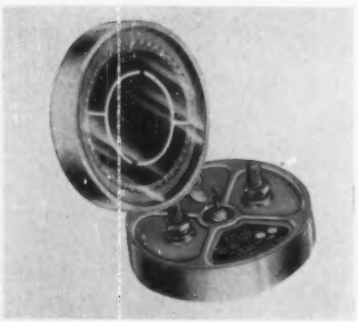
is compatible with all known hydraulic fluids, weighs only 2 oz and is 2⅜ in. long x 1 7/16 in. dia. Has in-line force feedback system, pressure-balanced construction and single nozzle design. Capacity is 0-2 gpm. Single nozzle reduces clogging by allowing particles as large as 200 micron to pass through. In-line force feedback reduces friction and assures proportional flow vs input signal. Pressure-balanced construction and flexible nylon seal make for low leakage. **Sanders Associates Inc, 95 Canal St, Nashua, NH.**

**Circle 316 on Reader Service Card**

## 3000-psi quick disconnect . . .

suitable for cramped locations, has pivoting release collar which can be operated with one finger or by a lanyard. Stainless steel coupling is self-sealing with zero leakage during disconnect; full pressure and no exposed seals after disconnect. Temperature rating is from —65 to 275 F. Available for tube sizes from ¼ to ½ in. **Symetrics Inc, 3100 Airport Ave, Santa Monica, Calif.**

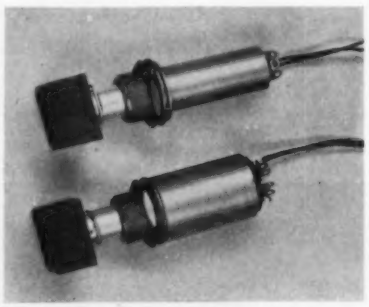
**Circle 317 on Reader Service Card**



## Encased photovoltaic cells . . .

are for high output and application even under adverse atmospheric conditions. Incorporate selenium cell which provides linear output with increased illumination through wide range; high sensitivity beginning at low light levels; resistance to shock and vibration, etc. Five models include: tinned silver-encased unit with glass front, 1¼ in. dia, hermetically or non-hermetically sealed; 2-in. electrotinned brass case model, filled with helium and hermetically sealed; two plastic-encapsulated cells, in either rectangular or circular shapes; and a Bakelite unit for use where atmospheric conditions are favorable. Standard diameters for plastic-encased circular cells range from 9/32 to 1¾ in. over-all; for rectangular cells, sizes range from ½ to 1¾ in. sq. **Daystrom Inc, Weston Instruments Div, 614 Frelinghuysen Ave, Newark 12, NJ.**

**Circle 318 on Reader Service Card**



## Solenoid hold-down switchlights . . .

are available in various arrangements from SPST to 6PST and SPDT to 8PDT, each with independent lamp circuit. When solenoid hold-down switch is actuated, coil is energized and holds pushputton in IN position. Pushbutton remains IN until coil is remotely deenergized. Switches are rated at 28 v dc, 50 milliamp to 2 amp, resistive with silver contacts and ¼ to 50 milliamp with gold contacts. The 175-ohm coil operates at 28 v dc. Holding force is 1½ lb; plunger travel, 7/16 in. Units can be installed in multi-station gang assemblies. Delivery is 3 to 4 wk. **Pendar Inc, 14744 Arminta St, Van Nuys, Calif.**

**Circle 319 on Reader Service Card**

## High-temp pressure transducer . . .

measures high or low pressures continuously at 600 F. Ambient temp limits on the stainless steel unit are from —320 to 650 F. Pressure ranges on gage and unidirectional differential models are from 0-2 psi through 0-5000 psi. Bidirectional differential model operates in ranges from ±1 through ±100 psi. Has combined non-linearity and hysteresis of less than ±0.75 in both high and low pressure ranges. **Statham Instruments Inc, 12401 W Olympic Blvd, Los Angeles 64.**

**Circle 320 on Reader Service Card**

## Static relay . . .

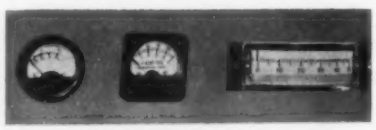
with meter movement sensitivity, responds to input power levels as low as 0.5 microw and handles up to 750-w, 60-c loads; yet, is said to be virtually unaffected by shock and vibration. Has no mechanical contacts, bearings or moving coils. Operates over temp range of —40 to 160 F and provides power amplification ratios in range of 90 to 100 db. Can be adjusted externally to vary sensitivity and will reset to normal open or closed position without external reset buttons, solenoids or interrupters. Operates directly from thermocouple or other low-level transducer without intermediate amplification in control, indicating and alarm systems. SP units available in either N.O. or N.C. configuration with single, double, or differential input positions. Size is 3 x 3½ x 3½ in.; price, approx $85. **Industrionic Div, Airborne Accessories Corp, 5456 W Washington Blvd, Los Angeles 16.**

**Circle 321 on Reader Service Card**

## All-transistor annunciator . . .

has 2 x 3-in. indication area and operates on closing or opening of a set of remote contacts. Can be used singly or in unlimited number, with all units served by a common acknowledging pushbutton and common sounding device. Available in two 110-v, ac models. One has dim glow and other is off under normal conditions. **Radiation Technology Inc, 657 Antone St, NW, Atlanta 18, Ga.**

**Circle 322 on Reader Service Card**



## Internally lit meters . . .

include 1-in.-barrel-dia and 1½-in. panel meters, as well as two side indicators. Built-in light source behind translucent scale is said to give better readability, especially where ambient light level is low. Light also can be used as built-in visual alarm or "off-on" indicator through simple circuit modification. Standard illumination is 28 v; optional, 6 or 14 v. **International Instruments Inc, 88 Marsh Hill Rd, Orange, Conn.**

**Circle 323 on Reader Service Card**

## Circular chart recorder . . .

is housed in a molded plastic case only 3¾ x 3¾ x 3 in. and mounts on 4-in. center. Thus, 9 recorders can be mounted in a panel area of only 1 sq ft. Records electrical voltage, current, or power, or any variable which can be converted to an equivalent electrical signal. No pen, ink or ribbon is required, since graph is printed by a stylus on pressure sensitive paper. Instrument contains three basic subassemblies: chart drive and clamping motor

continued on page 89



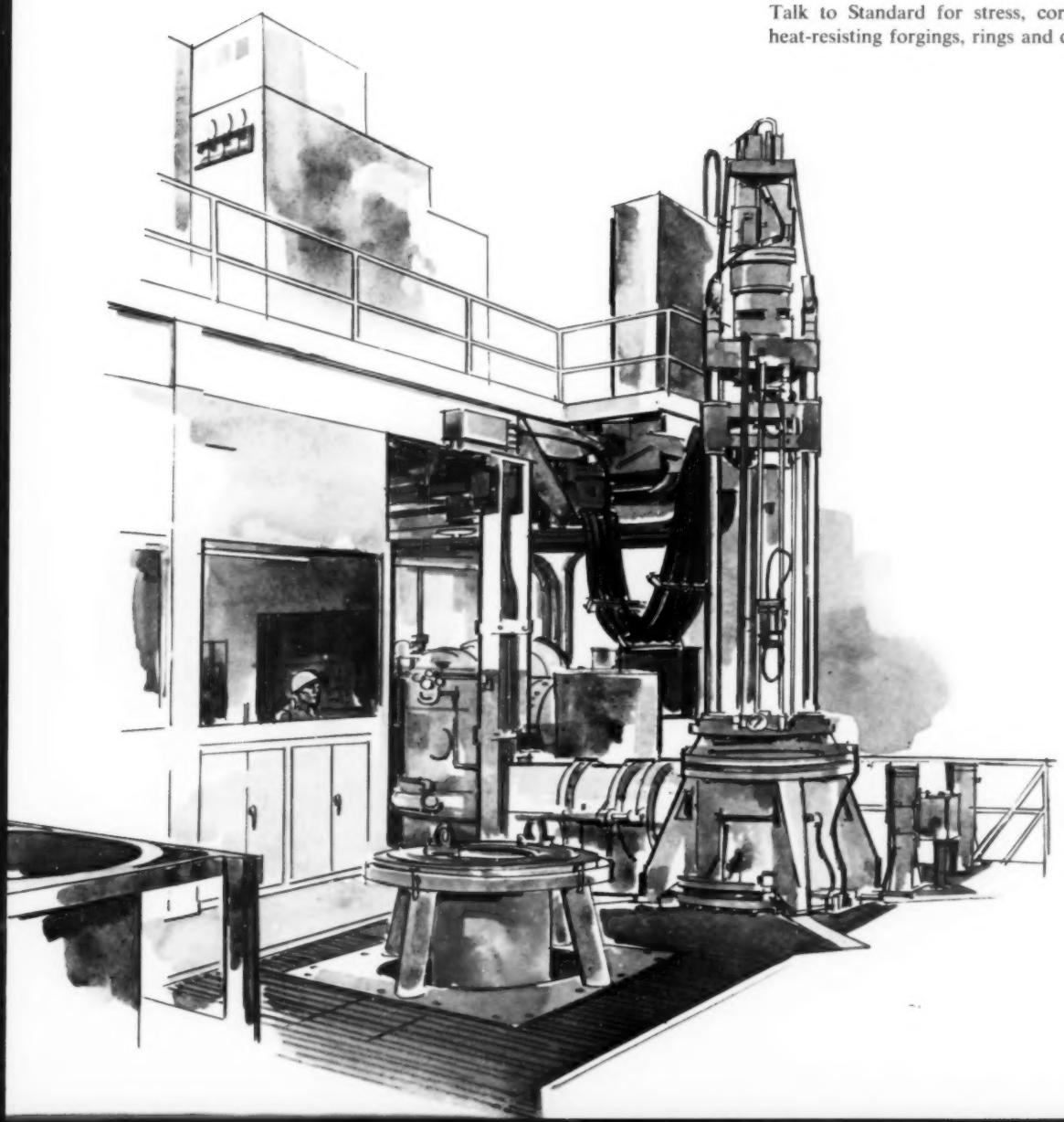
CIRCLE 85 ON READER SERVICE CARD→

# EXOTIC STEELS FROM STANDARD

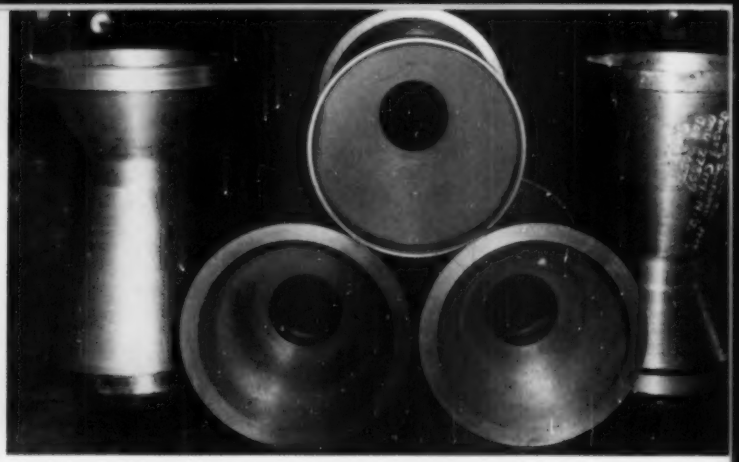
The vacuum arc remelt furnace pictured below is producing some of the largest ingots of the most advanced alloys in commercial production today—superstrength alloys for missiles, such as D-6, AMS-6428, 300M, and special high-temperature alloys for gas turbine, jet engine applications, A286, Waspalloy—to name a few.

This facility rounds out the most modern integrated steelmaking plant for special alloy forgings and rolled rings in the country—electric furnace steels, vacuum degassed, and vacuum remelted.

Talk to Standard for stress, corrosion and heat-resisting forgings, rings and castings.

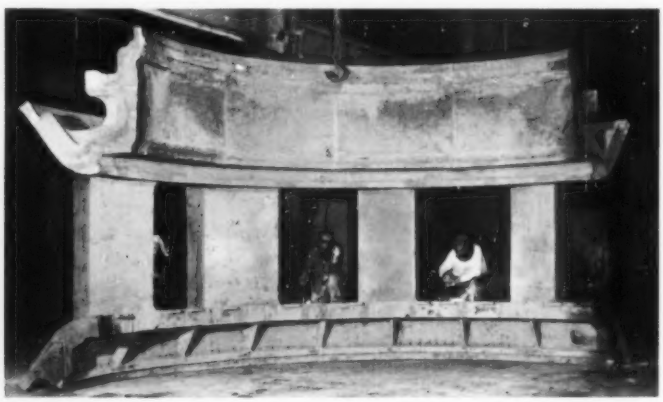


**QUALITY CONTROL IS SECOND TO NONE AT STANDARD.** Quality control at Standard is maintained by the most accurate, up-to-date testing equipment available. Laboratory facilities operate day and night to support our metallurgists, shop foremen, mill and machine operators—as well as plant management and, of course, our customers.



**STANDARD'S OPEN-DIE FORGINGS SUPPLY NATION'S LEADING INDUSTRIES.** Steel and nonferrous alloys can be worked in Standard's forge shop, including some hard-to-work metals such as titanium and super alloys. It can turn out forgings from 15 to 52,000 lb.; up to 45 inches in diameter; and up to 60 ft. in length. Major products include rotors and wheels for turbines, propeller shafts for ships, rolls for sugar, printing and rubber industries.

Standard's hundreds of customers represent every major industry in the world. Metal components of carbon and alloy steels, super alloys, and nonferrous alloys such as aluminum and titanium are supplied by Standard for an endless line of products. What particularly impresses our customers however, is the unique, personalized service we provide. See for yourself—bring your next problem to Standard.



**STEEL CASTINGS TO VIRTUALLY ANY SPECIFICATIONS.** The Standard foundry, one of the larger ones in the country, has turned out castings as light as 1 lb., and ranging up to 85,000 lb. They include some of the largest heads ever cast for dredge cutters and also vital components in huge hydroelectric projects throughout the world. Standard yields to none in the skill of its foundry engineers, metallurgists, molders, coremakers and core setters.

**PIONEERS IN ROLL-FORGED RINGS . . . STANDARD.** Standard's craftsmanship in forming metal rings for heavy industry dates back to 1856. The first all-forged weldless rings were produced in volume for the first time in 1870—at Standard. And much of the development work in forging weldless rings of high-alloy steels, aluminum and titanium has been done in Standard's Ring Department.

# Standard Steel Works Division

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Rings • Shafts • Car wheels • Gear blanks • Flanges • Special shapes

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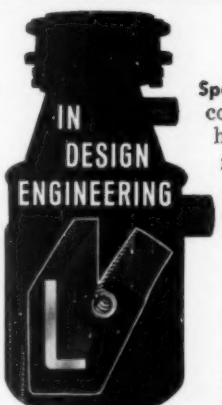
# OIL SEALS

**"Garlock KLOZURE Oil Seals have proven consistently satisfactory in sealing motor shafts."** W. T. Hedlund Manufacturing Company makes this report after specifying the seals to protect bearings and keep water from the motor of their Whirl-A-Way Food Waste Disposers. Hedlund finds other advantages of KLOZURE Oil Seals, too—less downtime, longer life, easier to install —and adds finally that ". . . leaky units have become negligible."

**Take a tip from Hedlund.** Design with Garlock KLOZURE Oil Seals. Where bearings need the best protection . . . on pumps and motors, on power shovels and lift trucks, in steel mills . . . KLOZURE Oil Seals prevent leakage of lubrication, seal out foreign matter. KLOZURE Oil Seals are oil and grease resistant, impervious to mild acids and alkalies, non-abrasive, and will withstand temperatures from −40°F to +250°F.




As a shaft seal for their Whirl-A-Way Disposer Units, W. T. Hedlund Manufacturing Co. selects Garlock KLOZURE Oil Seal Model 92 with rubber-covered metal case and stainless steel garter spring.

**Special seals are available** for service against harsh corrosives at temperatures to +500°F. If you have a particular sealing problem, get in touch with your local Garlock representative. He can furnish you with complete design and application information. Why not call him at the nearest of the 26 Garlock sales offices and warehouses throughout the U. S. and Canada. Or, write for Catalog AD-181. Garlock Inc., Palmyra, N.Y.

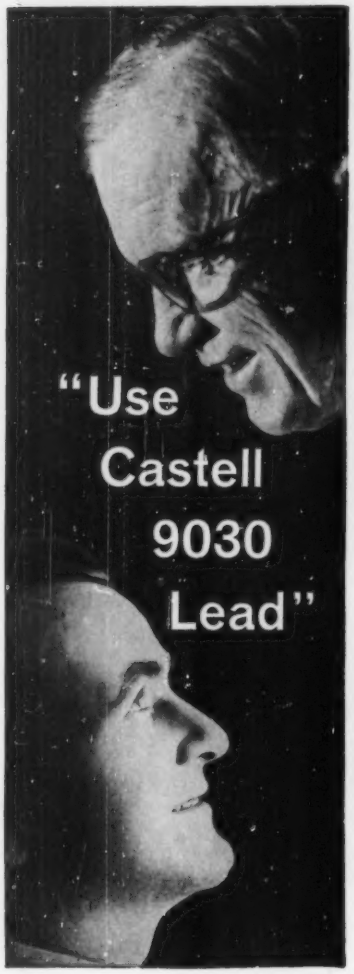
**Canadian Div.:** Garlock of Canada Ltd.

**Plastics Div.:** United States Gasket Company

**Order from the complete line** of quality Garlock products — Packings, Gaskets, Seals, Molded and Extruded Rubber, Plastic Products.

# GARLOCK

THE VOICE OF EXPERIENCE SAYS—



The most valuable lesson an upcoming engineer, architect or draftsman learns is "Use the best tools!" This means CASTELL #9030 Black Gold graphite-saturated lead that stays black without flaking, feathering or "burning out." Gives you crisp, opaque lines on all surfaces, including Cronar and Mylar base films. CASTELL #9030 never hesitates because of gritty spots. Remarkably uniform in all degrees, 7B to 10H, each as precise as a machine tool. Erases without leaving ghosts. Plastic tube with gold cap.

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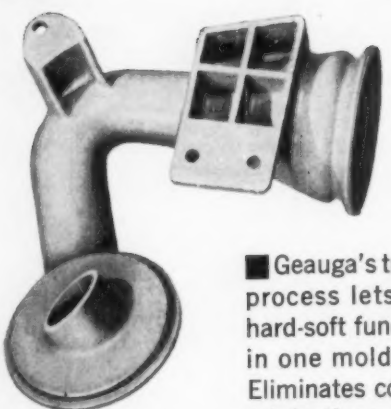

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■ Geauga's transfer molding process lets you combine hard-soft functional sections in one molding operation. Eliminates cost of cemented fabrications and possibility of field failure. And its low cost will surprise you.

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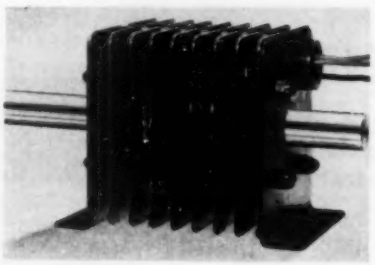
CIRCLE 205 ON READER SERVICE CARD

(hysteresis-induction type which operates at 240 rpm); gear train assembly; and meter movement (four available: D'Arsonval, cross coil, moving iron and ferrodynamic). As in other direct reading instruments, electrical input signal is fed directly into electrical meter movement. No amplification is needed even for signals as low as 10 microamp, since movement's deflection is unhindered during measuring portion of normal 6-sec cycle. Record is obtained by periodically clamping meter movement arm, causing stylus to press against underside of chart paper. Meter movements measure dc and ac quantities from thermocouple outputs to currents as high as 600 amp. Speed combinations available include 1, 7 and 30 hr per revolution or 1, 7 and 30 days per revolution. **Thomas A Edison Industries, Instrument Div, Lakeside Ave, West Orange, NJ.**

**Circle 324 on Reader Service Card**



**Electromechanical linear actuator . . .**
uses induction principles to deliver uniform long stroke. Contains only one moving part—the rod—and can be used to hold under load at any position or provide reciprocating motion. Stroke is up to 6 in. with standard units and unlimited in engineered products. Produces uniform output force throughout its stroke in either direction, with output force directly proportional to input power. Continuous duty holding force is up to 2 lb. Six models from stock operate on standard ac voltage and come furnished for foot mounting. **Skinner Precision Industries Inc, New Britain, Conn.**

**Circle 325 on Reader Service Card**

**Subminiature potentiometer . . .**
is low-price unit with high specifications (including ability to withstand steady state humidity) for use in printed circuits and other modular type applications where extreme angular resolution is not required. The single-turn, wirewound potentiometer measures ½ in. dia x 0.210 in., weighs 0.05 oz and is interchangeable with others of its type. Resistances range from 100 to 20k ohm; nominal resolution, down to 0.12%; power rating, 0.5 w at 158 F; and

continued on page 91

accurate
ductile iron cam

The cam way in this ductile iron cam for McNeil Bag-O-Matic Tire Curing Presses is used "as cast." Expensive contour machining has been eliminated. The only remaining operation is drilling.

For ductile iron castings requiring accuracy, smoothness and highest properties consider the unusual capabilities of
Morris Bean & Company,
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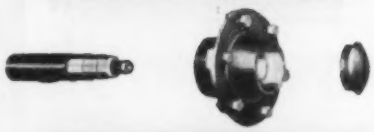

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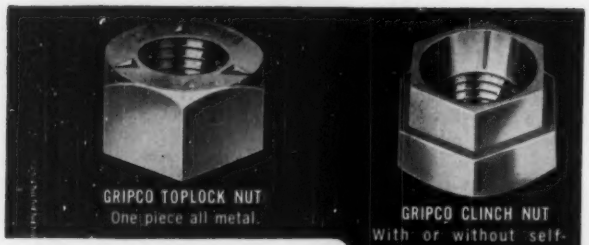

GRIPCO TOPLOCK NUT
One piece all metal.

GRIPCO CLINCH NUT
With or without self-locking threads. Hex collar prevents turning when torqueing bolt.

# You get these "extras" when you specify GRIPCO®

GRIPCO PILOT-PROJECTION WELD NUT
With or without self-locking threads. Centering collar positions nut and protects threads from weld spatter.

## FASTENERS—

**Service**—40 sales representatives all over the country for prompt, fast service.

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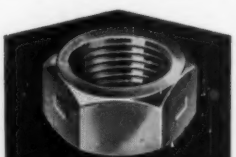

GRIPCO CENTERLOCK NUT
Locking feature in the center for fast feeding. Can be applied from either end.

GRIPCO COUNTERSUNK WELD NUT
With or without self-locking threads. Countersink protects threads from weld spatter.

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Something much finer in a dial thermometer: finer because it is the bourdon tube type of thermometer at its best... embodies the greater precision and lasting accuracy of the Marsh Pressure Gauge.

Both vapor tension and gas-filled types are available in either distant reading or rigid stem types. In the broad Marsh line you have a complete selection of temperature ranges, case sizes, styles, and finishes.

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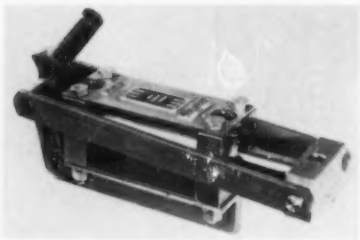
*Division of Colorado Oil & Gas Corporation*
Marsh Instrument & Valve Co. (Canada) Ltd., 8407 103rd St., Edmonton, Alberta, Canada, Houston Branch Plant, 1121 Rothwell St., Sect. 15, Houston, Texas. Eastern Seaboard Warehouse: Marsh Instrument Co., 1209 Anderson Ave., Fort Lee, N.J.



CIRCLE 208 ON READER SERVICE CARD

operating temp., —67 to 221 F. Meets steady state humidity requirements, 125 hr at 95 to 100% relative humidity, and can be used with conventional potting materials. Priced at $3 in production quantities. **Trimpot Div, Bourns Inc, 6135 Magnolia Ave., Riverside, Calif.**

**Circle 326 on Reader Service Card**



## Hydraulic hand pump . . .

suitable for pressures of 1000 to 2000 psi, has toggle linkage which enables operator to obtain a mechanical advantage of up to 3.5:1 at left end of stroke where linkage approaches dead center. Principle formerly applied to hand pumps for 3000-, 5000- and 10,000-psi service. **Mechanisms Co, 118 E 2nd St, Uhrichsville, Ohio.**

**Circle 327 on Reader Service Card**

## Step variable delay line . . .

is built of M-derived lumped constant sections and uses rotary switches for altering number of sections to achieve desired delay time. Delay time is up to 100 microsec; rise time ratio, 25:1 based on total delay; impedance, 200 to 1000 ohm; and incremental delay time per step, from 1/10 to 1/100 of total delay. **Gray & Kuhn Div, Burnell & Co, 80 Swalm St, Westbury, LI, NY.**

**Circle 328 on Reader Service Card**

## Moistureproof solenoid valves

include magnetic circuits completely encapsulated in epoxy. Can be supplied with rectifier diodes molded into the circuitry, allowing valves to operate as dc units from ac power source. Units can be used with or without outer housing, can be rotated 360° and are reversible. Available with spade terminals of PVC leads. **Peter Paul Electronics Inc, 251 Whiting St, New Britain, Conn.**

**Circle 329 on Reader Service Card**

## Beryllium copper strip . . .

with tensile strength to 190,000 psi, is mill heat-treated. Formability is said to exceed all previous standards for this type alloy product. In addition to eliminating need for customer heat treatment, processes also thermally iron material to high degree of flatness and reportedly provide better uniformity throughout a coil and between lots. **Brush Beryllium Co, 5209 Euclid Ave, Cleveland 3.**

**Circle 330 on Reader Service Card**

## Single- and double-acting dashpots . . .

use liquid compressibility for energy absorption applications from 10 to 8,860,000 in.-lb. Sixty-six standard models range in size from 1⅛ in. long x ½ in. dia to 70 in. long x 8½ in. dia. **Taylor Devices Inc, 200 Michigan Ave, North Tonawanda, NY.**

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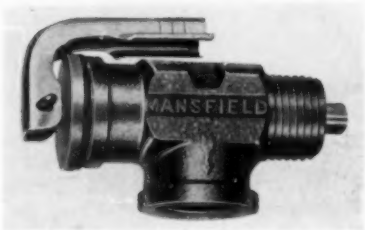



## Relief valves . . .

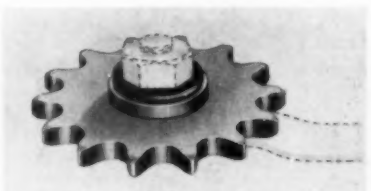
are available with 15- to 200-psi settings and have Neoprene seals, stainless steel springs and cast red brass bodies. Some are equipped with calibrated adjusting keys. Standard setting is 125 psi. Suitable for use wherever pop-off or bypass type relief units are needed. **Mansfield Sanitary Inc, Perrysville, Ohio.**

**Circle 332 on Reader Service Card**

## Synchronous induction motor . . .

is single-phase, 60-c, 115-v, capacitor start-run type, using 3-microfarad capacitors. Produces pull-out torque of 8 oz-in. min, compared with 3 oz-in. of conventional hysteresis synchronous models. Measures 1.88 in. dia and 2.25 in. long. **Task Corp, 1009 E Vermont Ave, Anaheim, Calif.**

**Circle 333 on Reader Service Card**

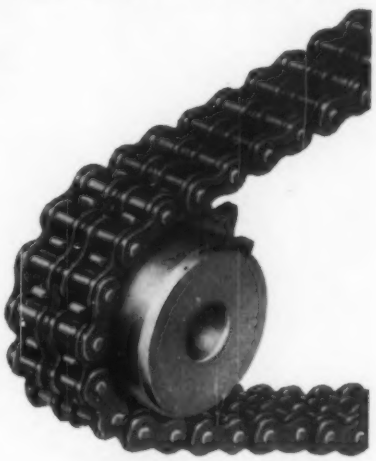


## Fully assembled idler sprocket

has oil-impregnated bearing which is a press fit in the sprocket bore and a slip fit over the case-hardened steel journal to eliminate "run out." Steel washers press fit on journal to complete assembly and provide proper lateral clearance between

continued on page 92

A Morse answer



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Superior fatigue resistance

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Distributor-stocked

Got a chain problem? Call your Morse distributor. He's listed in the Yellow Pages.

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Morse Chain Co., Dept. 4-61, Ithaca, N.Y. Export Sales: Borg-Warner International, Chicago 3, Ill. In Canada: Morse Chain of Canada, Ltd., Simcoe, Ont.

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Here is a drafting table that combines truly imaginative engineering with intimate knowledge of *today's* drafting procedures. Exclusive new torsion bar mechanism permits smooth, silent *fingertip* adjustment of board tilt. Simple counterbalance adjustment compensates for weight added to board in the form of drafting machines and lamps. *Flexible reference facilities* may be used from either side of desk. In addition, *space economies of up to 35% are possible!*

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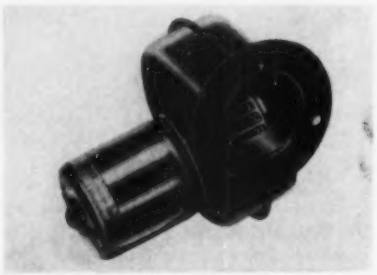
Hamilton Manufacturing Company, Two Rivers, Wisconsin


working parts. Sprocket teeth are machined, not stamped, for smooth chain engagement with max contact surface. Sizes range from $\frac{3}{8}$ to 1½-in. chain pitch. Length through bore is 1 in. and hub diameter, 1½ in. From stock at $4.90 to $6.50 (1 and 1½-in. chain pitch sizes made-to-order). **Diamond Chain Co. Inc, 402 Kentucky Ave, Indianapolis 7.**

**Circle 334 on Reader Service Card**



**Subfractional-hp blower . . .** has unitized housing of cold rolled steel with baked enamel finish. Air delivery has been increased to 60 cfm for single unit at 3200 rpm and 120 cfm for double unit at 3100 rpm. Powered by 2P shaded pole induction motor, 115 v ac, 60 c. Other voltages, as well as 50-c operation, are available. Suitable for cooling electronic equipment and for induction heating. **Heinze Electric Co, 685 Lawrence St, Lowell, Mass.**

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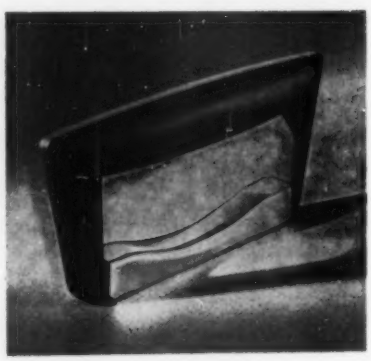
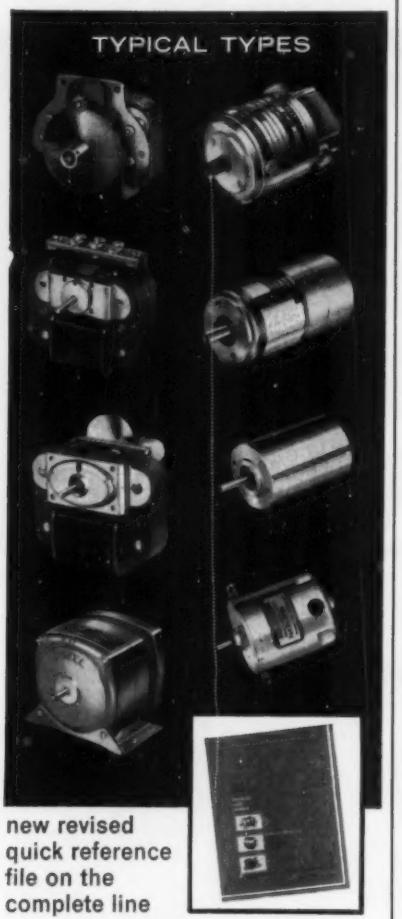


**Polypropylene handle . . .** is suitable for heat-and chemical-resistant installations. Fastens by means of a steel bracket which is screwed or riveted to case. Steel-contoured cover cap, which snaps on over bracket, is available in variety of finishes. Handle, itself, is supplied in any of four stock colors or matched in color on volume orders. In tests, handle lifted a 75-lb load 10,000 times without developing signs of wear or fracture. **Philadelphia Handle Co, 1643 Haddon Ave, Camden 3, NJ.**

**Circle 336 on Reader Service Card**

*Select the exact a-c or d-c small motor you need... from the wide Barber-Colman line*




new revised quick reference file on the complete line

. . . this helpful guide illustrates and gives typical specifications on Barber-Colman subfractional horsepower motors. Ask for *Quick Reference File F-9765* . . . it covers the following:

A-C SHADED-POLE MOTORS
unidirectional • reversible
synchronous • geared
A-C AND D-C TACH GENERATORS
D-C PRECISION MOTORS
BATTERY-OPERATED MOTORS
A-C 400-CYCLE MOTORS
BLOWERS, GEARHEADS
ULTRA-SENSITIVE RELAYS

BARBER-COLMAN COMPANY
DEPT. R, 1912 ROCK STREET, ROCKFORD, ILLINOIS

CIRCLE 209 ON READER SERVICE CARD

**Ganging potentiometer . . .**
is 1⅞-in. single turn, wirewound unit, completely encased in precision machined aluminum. Power rating is 2.5 w with max temp rise of 140 F. Noise is reduced by multi-finger contact brush and resistance wire bonded to card. Resistance element can be linear or nonlinear. Rotation is continuous or brush limited to stop on overtravels. Standard ranges include 1000, 5000, 10,000, 25,000, 50,000 and 100,000 ohm. Supplied as single or multiple ganged units, which can be independently phased. **DeJur-Amsco Corp, 45-01 Northern Blvd, Long Island City 1, NY.**

**Circle 337 on Reader Service Card**

**Combination drawing table and desk . . .**
is L-shape unit made of steel and finished in two-tone baked enamel. Drafting table can be adjusted in height from 30 to 45 in. and at any angle from 0 to 90°. Plastic-top desk on one side of unit has large, shallow tool and catalog drawers, and tubular legs with floor levelling devices. Unit includes three electrical outlets. **Stacor Equipment Co, 285 Emmet St, Newark 5, NJ.**

**Circle 338 on Reader Service Card**

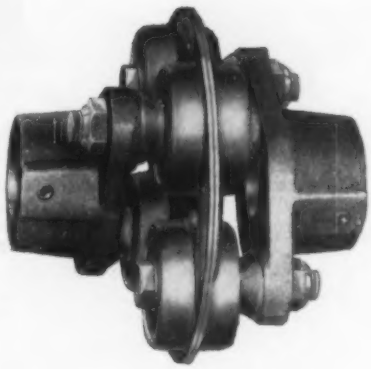
**Temperature recorder . . .**
operates on a pyrometer principle, using output from a thermocouple junction through a temp compensator to cause deflection of a highly sensitive galvanometer. Supplied with 6-ft thermocouple, which is directly connected to recorder's rear terminals. Any temp span from a 500 to 2500 F range is available. Priced at $139.50. **Rustrak Instrument Co, 130 Silver St, Manchester, NH.**

**Circle 339 on Reader Service Card**

**Logic-symbols templet . . .**
contains symbols for use on basic logic and engineering logic diagrams associated with digital processing systems. Made of green-tinted plastic with beveled cutouts. Overall size: 7⅛ x 4 in. Price: $3. **Rapidesign Inc, PO Box 429, Burbank, Calif.**

**Circle 340 on Reader Service Card**

A Morse answer



**Morflex couplings**

*...when the problem involves vibration and misalignment*

Isolate vibration
Cushion shock
Absorb misalignment
Torsionally flexible
Impervious to water, dirt, oil
Arrest electrolysis
Distributor-stocked

Got a coupling problem? Call your Morse distributor. He's listed in the Yellow Pages.

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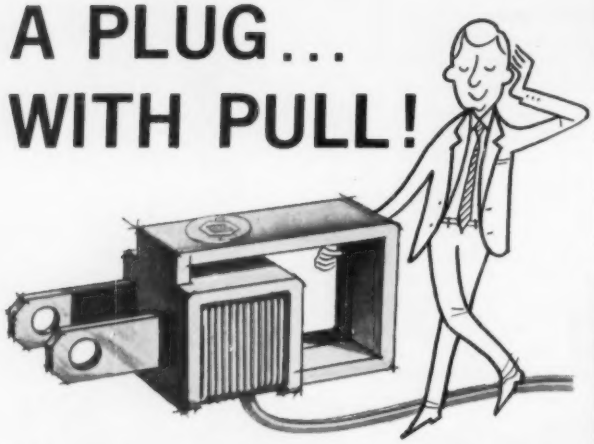
Morse Chain Co., Dept. 4-61, Ithaca, N.Y. Export Sales: Borg-Warner International, Chicago 3, Ill. In Canada: Morse Chain of Canada, Ltd., Simcoe, Ont.

CIRCLE 93 ON READER SERVICE CARD

# A PLUG... WITH PULL!



This unusual cord set, introduced and patented by Miller Electric, is imaginatively designed to make removal from any outlet easy. And it discourages "wire yanking" habits that may cause failures in ordinary plugs.

A Miller **Finger Pull Plug** with unlimited color-co-ordinating possibilities makes any product more functional, more attractive, and effectively displays your trademark, too.

Whether you select from the industry's largest line of stock vinyl cord set components, or require one with custom designed parts, it may cost no more for Miller to **give your product a plug . . . with pull!**

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**MILLER ELECTRIC CO.**

120 Main Street • Pawtucket, R. I.

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# GOLD SICON withstands 500° F.

Gold SICON protects the grill and grill pouch of this attractive Quaker space heater under temperatures of over 500°F., without peeling, flaking, powdering or discoloring. *And it will retain its bright appearance indefinitely!* Do as Heil-Quaker did. Test SICON . . . up to 1000°F. for Sicon-Aluminum or black . . . from 500° to 650°F. in gold or other decorative colors. Write for Sicon brochure and free sample offer . . . today! **Write Dept F-31.**

**SICON, protects and preserves—wherever there is heat.**

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25 years of progress in tiny parts

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- ☐ Simplify assembly
- ☐ Improve appearance with

# GRC DIE CAST ZINC ALLOY & MOLDED NYLON FASTENERS

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Head Diameters: ⅛" thru 1⅛"
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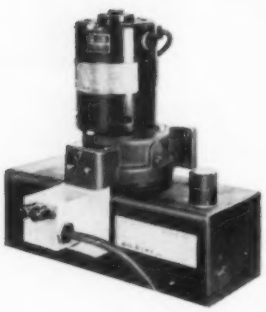
# A complete OIL-DYNE hydraulic unit could fit on this page — with room to spare!



If you still believe that hydraulic units must be big and bulky, you just haven't seen Oil-Dyne's miniature power package! And if you think the motor or pump must run constantly, you haven't heard that an Oil-Dyne motor and pump run ONLY while the cylinder piston is in motion. Perhaps, too, you didn't know that Oil-Dyne has eliminated all the complex external valving for directional control . . . and that when you shut off an Oil-Dyne reversible pump, the piston is automatically locked in position, and stays there indefinitely. Just to make sure you're aware of what's happened in hydraulics since Oil-Dyne pioneered miniaturization, you ought to write for our Catalog 21-E.

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**CIRCLE 94 ON READER SERVICE CARD**

# DESIGN LITERATURE

### The National Watercraft Collection

*HOWARD I CHAPELLE. US Government Printing Office, Washington 25, DC, 8½ x 11, 327 pp. $3.50.*

Bulletin No 219 of the US National Museum (Smithsonian Institute) describes the collection of ship models, plans, photos and other data in the watercraft collections. Of particular interest are the items which reflect the design changes resulting from technological improvements. These are most evident with the advent of steam propulsion and the change from wood to metal as the principal structural material.—JJK

### Electronics in Engineering (2nd Edition)

*W RYLAND HILL, professor of electrical engineering, Univ of Washington. McGraw-Hill Book Company Inc, 330 West 42nd St, New York 36. 6¼ x 9¼, 340 pp. $8.*

For engineering and science students not majoring in electrical engineering, it covers vacuum and solid-state electronic devices, electronic circuits, and circuit analysis. The book presumes a prior knowledge of circuit theory from a basic electrical engineering or physics course. Topics are vacuum and gas-filled tubes, transistors, rectification, amplification, feedback, the cathode-ray oscilloscope, resonance, oscillators, and transducers. Sketches of tubes and semiconductors are simple and easy to understand.

### Introduction to the Kinematic Geometry of Gear Teeth

*ALLAN H CANDEE. Chilton Company, Philadelphia 39. 6 x 9½, 204 pp. $12.50.*

This book presents information and explanations about gear-tooth contact of spur gears in a form useful for reference, and suitable for study. The basic problem concerns contact between tooth profiles in a plane, and all related problems can be solved by two-dimensional plane geometry and kinematic geometry. Tooth generation and tooth design are treated as an important part of gear design. The important feature of the book is method. None of the problems treated is new; but the solutions are obtained by thinking geometrically in a way that will appeal to the practical-minded.

A graphical method is employed that consists of geometrical constructions by lines and points, combined with numerical calculations of distances and angles. Considerable use is made of the ideas of instant centers and centers of curvature. Simple formulas can then be derived that yield acceptably accurate values by comparatively short arithmetical calculations. Tables of recently computed coordinates of points on the involute of a circle and on involute tooth profiles are presented in an appendix.

### Other Books of Interest

**Specifying the Characteristics of Auxiliary Equipment for Shock and Vibration Measurements**
American Standards Association Inc, 10 E 40th St, NY 16. 8 x 11, 11 pp. 80¢.

**Involute Splines, Serrations and Inspection**
American Society of Mechanical Engineers, 29 W 39 St, NY 18. 8¼ x 11, 108 pp. $5.
*This American standard is numbered ASA B5.15-1960.*

## ABSTRACTS FROM THE LITERATURE

### Tunnel-diode Applications

Tunnel diodes can be used to amplify, switch, or generate oscillations and can be combined with transistors to take advantage of favorable features of both devices. Basic circuit simplicity, high-speed operation, and various methods of combining tunnel diodes with transistors are illustrated and described.

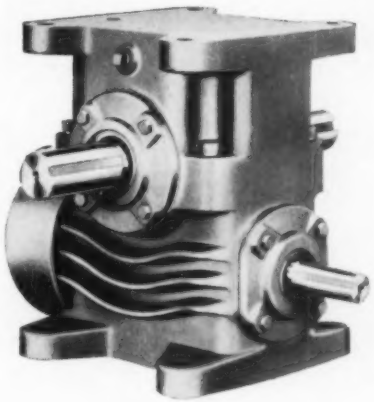
*"Tunnel Diode Applications," by C. D. Todd, Hughes Aircraft Co. Presented by AIEE Tunnel Diode Symposium, Feb 17, 1960.*

### Journal-bearing Analysis

This paper analyzes journal-bearing equations by using phase-plane methods—resulting in velocity-vs-displacement plots of the journal eccentricity. It is believed that this type of analysis exhibits previously known journal-bearing characteristics more clearly

continued on page 96

A Morse answer



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Ratios 5:1 to 3600:1
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and introduces an explanation of certain other characteristics which were previously obscure.

For example, all possible motions of the journal that can result from varying such parameters as journal rotational speed, load, eccentricity, and so on, are clearly shown.

*"Phase Plane Analysis of Dynamically Loaded Journal Bearings," by H. T. Albachten, Internal Business Machines, San Jose, Calif. ASME Paper No 61-LUBS-12.*

### Sealing of Hazardous Fluids

Outlines the general types of equipment and methods employed by one chemical manufacturing company in the handling and sealing of several hazardous fluids. The pertinent features of each equipment type are outlined, and several types of equipment are illustrated.

*"Sealing of Hazardous Fluids," Arthur L. Decker, Ethyl Corp. British Hydromechanics Research Assoc, International Meeting on Fluid Sealing, April 17-19, 1961, Ashford, Kent, England.*

## CATALOGS AND BULLETINS

To obtain copies of literature described below, circle corresponding number in postcard inside back cover. For those catalogs and bulletins available only when requested on company letterhead, see page 100.

VARIABLE-SPEED DRIVES—Catalog 700, 112 pp. Contains dimensions and dimension drawings of integral- and fractional-hp units. Price section covers 2:1 to 6:1 variations and max variations. Tables indicating load characteristics and torque ratings are included. Sterling Electric Motors Inc, 5401 Telegraph Rd, Los Angeles 22.

**Circle 350 on Reader Service Card**

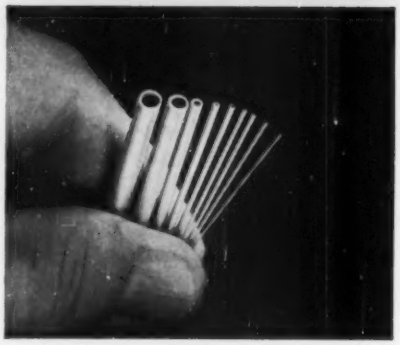
ROTARY AIR PRODUCTS—Catalog 660, 12 pp. Deals with six sizes of air motors, 1/20 to 7 hp; compressors ranging from 0.6 to 45 cfm, up to 30 psig; and vacuum pumps, ranging from 0.6 to 50 cfm, up to 28 in. Hg. Presents specifications, photographs, dimension drawings and performance curves. (See Letterhead Requests for larger catalog). Gast Mfg Corp, 23102 Hwy M-139, Benton Harbor, Mich.

**Circle 351 on Reader Service Card**

VALVES—Bulletin 91051, 6 pp. Supplies photographs, specifications, design features, dimensions, etc. of miniature, special and 2-, 3- and 4-way valves; cylinders; pumps and special controls. Airmatic Valve Inc, 7313 Associate Ave, Cleveland 9.

**Circle 352 on Reader Service Card**

NEED FINE TUBING IN ALUMINUM ALLOYS?



● Production mills provide rough drawn aluminum alloy tubing in the standard, large sizes. But the redrawing of fine, seamless tubing with any needed O.D. between 0.010″ and 0.375″ and wall thicknesses from 0.035″ ±0.0005″ to 0.001″ ±0.00025″ is UNIFORM's specialty. UNIFORM TUBES provides the precision aluminum alloy tubing such as that which goes into the fabrication of lightweight, highly accurate instrument pointers and other critical applications.

Through skills developed over the years and by continuing devotion to precision craftsmanship, UNIFORM meets close tolerances in every dimension even cutting tubing in lengths to ±0.003″. Tubing ends are always free of burrs and concentricity is preserved.

Fine tubing drawn to your specification is available in high purity aluminum and aluminum alloys 1080-C, 1100, 2024, 3003, 5052, 6061, 6951, 7075 and the new high-strength alloy UT-58.

Even though tubing is drawn to your exacting requirements, if you need delivery "yesterday," UNIFORM will produce fastest delivery possible. Write for information on this tubing or on tubular parts fabricated "at the mill" from these alloys as well as alloys of copper, nickel, steel and the precious metals. Sizes up to ⅜-inch O.D. on application.

UNIFORM TUBES, INC. COLLEGEVILLE 2, PA.
HUxley 9-7276 TWX-CGVL 1044

**GAGES**—Catalog DH-54, 32 pp. Describes and illustrates construction features of pressure, vacuum and compound indicating gages, whose movements incorporate helical rollers instead of gears or teeth. Supplies sizes, ranges, type of bourdon tubes, connections, accuracy, recommended uses, etc. Includes dimension drawings. Helicoid Gage Div, American Chain & Cable Co Inc, Bridgeport 2, Conn.

**Circle 353 on Reader Service Card**

**ELECTROMAGNETIC CLUTCHES, BRAKES**—Manual 361, 46 pp. Carries specifications, dimensional data, schematics, performance curves, etc. of small standard and pancake clutches, brakes and clutch/brake combination units. Also covers torque indicators, torque standards and multispeed transmissions. Oscillograph recordings of response time measurement are given. Autotronics Inc, Florissant, Mo.

**Circle 354 on Reader Service Card**

**WHEEL PACKAGES**—Bulletin 613, 20 pp. Covers packages containing spindles, bearings, hubs, closure seals and caps and tires that carry loads from 500 to 3000 lb and are designed for farm implements and industrial products. Load vs speed charts, dimension drawings and photographs are offered. French & Hecht Div, Kelsey-Hayes Co, PO Box 690, Davenport, Ia.

**Circle 355 on Reader Service Card**

**RELAYS**—Bulletin, 20 pp. Lists performance features, electrical specifications and prices of relays, steppers, sensitrols, solenoids, contractors, rectifiers and related items from stock. Universal Relay Corp, 42 White St, New York 13.

**Circle 356 on Reader Service Card**

**GAS AND VAPOR ELECTRON TUBES**—Handbook SP 1042, 12 pp. Describes standard and subminiature voltage regulator and voltage reference tubes, rectifiers, thyratrons, decade counters and radiation counter (Geiger-Mueller) tubes, tabulating their operating characteristics and ratings. Raytheon Co., Industrial Components Div, 55 Chapel St, Newton 58, Mass.

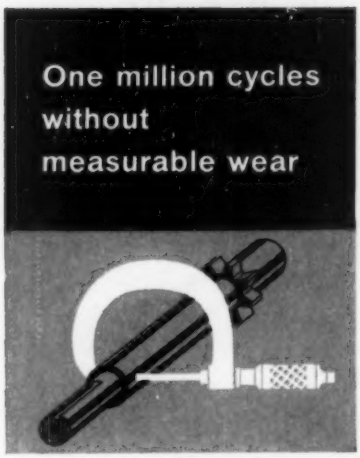
**Circle 357 on Reader Service Card**

**URETHANE SEALS AND PACKINGS**—Catalog, 8 pp. Discusses physical characteristics of urethane elastomer and its use in sealing hydraulic and pneumatic equipment; manufacturing tolerances allowed with seals; types of moving part surface finishes; housing dimensions; fitting "U" cups into existing grooves; and designing housing for new installations. Illustrates and tabulates sizes and types of available seals and packings. Disogrin Industries, Div of Pellon Corp, 510 S Fulton Ave, Mt Vernon, NY.

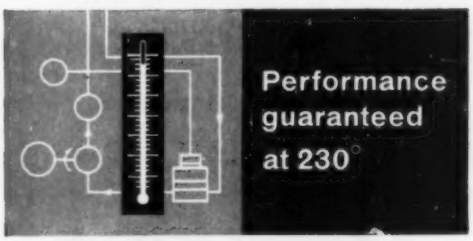
**Circle 358 on Reader Service Card**

continued on page 98

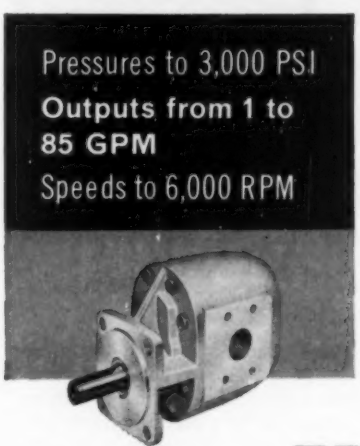

# BERRY/DOWTY* gear pumps




The Berry/Dowty line of hydraulic gear pumps has been subjected to exhaustive endurance tests. A Model GPA3/170 (rated output 24.5 GPM at 1800 RPM and 2000 PSI) was put through a one million cycle 0-2000 PSI test, with the final 200,000 cycles at 230° F. There was no measurable wear as a result of this test. In this and other tests, volumetric and mechanical efficiency has increased slightly from beginning to end of test, a result of the self-compensating design.




Performance and warranty are unaffected by system temperatures of 230° F. provided minimum operating oil viscosity is 50 SSU. Volumetric efficiencies of 95% at 2000 PSI are normal under these conditions.




Value analysis (price, performance and reliability) proves the economy of Berry/Dowty Hydraulic Gear Pumps. Wire or phone today (Corinth, Miss., ATlantic 6-5541, Dept. K) for test units for evaluation on your equipment.

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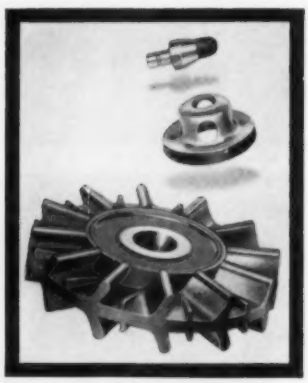

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**HYDRO-PNEUMATIC 4-WAY VALVE**—Data sheet 474-01.201-1, 3 pp. Contains specifications, dimensions, photographs and installation drawings of the pneumatic diaphragm-operated mechanism for hydraulic actuation of cylinder operators. B-I-F Industries, PO Box 276, Providence, RI.

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SILICON DIFFUSED RECTIFIERS—Catalog, 6 pp. Outline drawings and mechanical and electrical specifications cover units ranging from 50 to 600 v PIV and from 250 milliamp to 22 amp. Raytheon Co, Semiconductor Div, 215 1st Ave, Needham, Mass.

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PLUG-IN LIMIT SWITCH—Data sheet, 1 p. Outlines operating characteristics and electrical rating of switch that operates four circuits with each direction of the lever. Illustrations include dimension drawings and contract arrangement diagrams. Micro Switch Div, Minneapolis-Honeywell Regulator Co, Freeport, Ill.

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LOW-VOLTAGE MOTOR CONTROLS—Brochure 3100-PRD-202, 16 pp. Shows dimensions and weights and construction details of magnetic, reduced volt-

continued on page 100


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CERAMIC-TO-METAL COMPONENTS—Brochure, 8 pp. Discusses their applications and tabulates dimensions of tubular feedthrough, terminal insulator and cable end seal series. Describes company's engineering, manufacturing and testing facilities, Ceramics International Corp, 39 Siding Pl, Mahwah, NJ.

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ELECTRONIC WELDING—Technical report, 17 pp. Traces resistance welding process; significant factors in resistance welding; evaluation of weldability of various materials; weldability of clad materials; and dissimilar materials. Illustrated with photographs of magnified welds, charts and graphs. Vacuum Tube Products Div, Hughes Aircraft Co, 2020 Short St, Oceanside, Calif.

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MINIATURE BALL BEARINGS—Catalog and technical handbook, 64 pp. Furnishes complete specifications and cross-section drawings of miniature and instrument-size bearings. Includes data on bearing selection, materials, load ratings, torque and vibration testing, lubrication, measurements, tolerances, failure analysis, bearing applications, etc. Miniature Precision Bearings Inc, Keene, NH.

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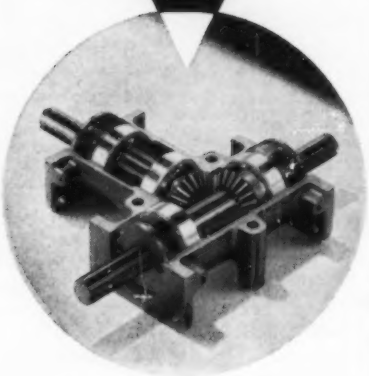

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# INDEX TO ADVERTISERS

*This index is published as a convenience to the readers. Every care is taken to make it accurate but PRODUCT ENGINEERING assumes no responsibilities for errors or omissions*


| | Page |
|---|---|
| Airborne Accessories Corp. | 101 |
| Alemite Div., Stewart-Warner Corp. | 54 |
| Allen-Bradley Co. | 2 |
| Armstrong Cork Co., Industrial Div. | 35 |
| Auburn Mfg. Co. | 88 |
| Baldwin-Lima-Hamilton Corp., Standard Steel Works Div. | 85-86 |
| Barber-Colman Co. | 93 |
| Berry Hydraulics Div., Oliver Tyrone Corp. | 97 |
| Bodine Electric Co. | 34 |
| Bower Roller Bearing Div., Federal-Mogul-Bower Bearings, Inc. | 40 |
| Celanese Polymer Co., Div., Celanese Corp. of America | 7 |
| Chace Co., W. M. | 28 |
| Combination Pump Valve Co. | 51-52 |
| Continental-Diamond Fibre Co., Subs. of The Budd Co. | 48 |
| Continental Felt Co. | 102 |
| Curtis Universal Joint Co., Inc. | 99 |
| Dow Metal Products Co., Div., Dow Chemical Co. | 83 |
| Duff-Norton Co. | 82 |
| du Pont de Nemours & Co., (Inc.), E. I., Film Dept. | 10 |
| Elastic Stop Nut Corp. of America | 30-31 |
| Electric Wheel Co., Div. of Firestone Tire & Rubber Co. | 89 |
| Emcor-Ingersoll Products Div., Borg-Warner Corp. | 29 |
| Emerson Electric of St. Louis | 4th Cover |
| Faber-Castell Pencil Co., Inc., A. W. | 88 |
| Fairbanks Co. | 90 |
| Fairchild Engine & Airplane Corp., Stratos Div. | 96 |
| Fenwal, Inc. | 25 |
| Flexonics Corp., Subs. Calumet & Hecla, Inc. | 47 |
| Garlock, Inc. | 87 |
| Geauga Industries Co., Subs. Carlisle Corp. | 88 |
| General Electric Co., Silicone Products Dept. | 56 |
| Gleason Works | 39 |
| Goodyear Tire & Rubber Co., Industrial Products Div. | 14-15 |
| Goshen Rubber Co., Inc. | 98 |
| Gries Reproducer Corp. | 94 |
| Grip Nut Co. | 90 |
| Hamilton Mfg. Co. | 92 |
| Handy & Harman | 46 |
| Hubbell, Inc., Harvey, Machine Screw Dept. | 101 |
| Hydreco Div., New York Air Brake Co. | 43 |
| Johns-Manville Corp., Packings & Friction Materials Div. | 38 |
| Kaupp & Sons, C. B. | 32 |
| Kopp Glass, Inc. | 53 |
| Link-Belt Co. | 11 |
| Lucas-Milhaupt Engineering Co. | 98 |
| McLouth Steel Corp. | 33 |
| Marsh Instrument Co., Div. of Colorado Oil & Gas Corp. | 90 |
| Masland Duraleather Co., The | 44 |
| Midland Industrial Finishes Co. | 94 |
| Midwest Steel Div., National Steel Corp. | 5 |
| Miller Electric Co. | 94 |
| Miller Fluid Power Div., Flick-Reedy Corp. | 41 |
| Morris Bean & Co. | 89 |
| Morse Chain Co., A Borg-Warner Industry | 91, 93, 95 |
| National Seal Div., Federal-Mogul-Bower Bearings, Inc. | 3rd Cover |
| New Hampshire Ball Bearings, Inc. | 78 |
| New York Air Brake Co., Hydreco Div. | 43 |
| Newton-New Haven Co. | 99 |
| Oil-Dyne, Inc. | 94 |
| Phillips Chemical Co., Subs. Phillips Petroleum Co. | 42 |
| Robbins & Myers, Inc. | 49 |
| Russell, Burdsall & Ward Bolt & Nut Co. | 16 |
| Standard Steel Works Div., Baldwin-Lima-Hamilton Corp. | 85-86 |
| Stewart-Warner Corp., Alemite Div. | 54 |
| Tomkins-Johnson Co. | 45 |
| Torrington Co. | 50 |
| Uniform Tubes, Inc. | 96 |
| United Electric Controls Co. | 13 |
| Warner Electric Brake & Clutch Co. | 36 |
| Weirton Steel Co., Div., National Steel Corp. | 5 |
| Wiegand Co., Edwin L. | 37 |
| Worthington Corp. | 2nd Cover |



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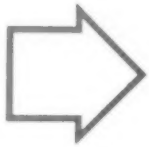

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| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 21 | 41 | 61 | 81 | 101 | 121 | 141 | 161 | 181 | 201 | 221 | 241 | 261 | 281 | 301 | 316 | 331 | 346 | 361 | 376 |
| 2 | 22 | 42 | 62 | 82 | 102 | 122 | 142 | 162 | 182 | 202 | 222 | 242 | 262 | 282 | 302 | 317 | 332 | 347 | 362 | 377 |
| 3 | 23 | 43 | 63 | 83 | 103 | 123 | 143 | 163 | 183 | 203 | 223 | 243 | 263 | 283 | 303 | 318 | 333 | 348 | 363 | 378 |
| 4 | 24 | 44 | 64 | 84 | 104 | 124 | 144 | 164 | 184 | 204 | 224 | 244 | 264 | 284 | 304 | 319 | 334 | 349 | 364 | 379 |
| 5 | 25 | 45 | 65 | 85 | 105 | 125 | 145 | 165 | 185 | 205 | 225 | 245 | 265 | 285 | 305 | 320 | 335 | 350 | 365 | 380 |
| 6 | 26 | 46 | 66 | 86 | 106 | 126 | 146 | 166 | 186 | 206 | 226 | 246 | 266 | 286 | 306 | 321 | 336 | 351 | 366 | 381 |
| 7 | 27 | 47 | 67 | 87 | 107 | 127 | 147 | 167 | 187 | 207 | 227 | 247 | 267 | 287 | 307 | 322 | 337 | 352 | 367 | 382 |
| 8 | 28 | 48 | 68 | 88 | 108 | 128 | 148 | 168 | 188 | 208 | 228 | 248 | 268 | 288 | 308 | 323 | 338 | 353 | 368 | 383 |
| 9 | 29 | 49 | 69 | 89 | 109 | 129 | 149 | 169 | 189 | 209 | 229 | 249 | 269 | 289 | 309 | 324 | 339 | 354 | 369 | 384 |
| 10 | 30 | 50 | 70 | 90 | 110 | 130 | 150 | 170 | 190 | 210 | 230 | 250 | 270 | 290 | 310 | 325 | 340 | 355 | 370 | 385 |
| 11 | 31 | 51 | 71 | 91 | 111 | 131 | 151 | 171 | 191 | 211 | 231 | 251 | 271 | 291 | 311 | 326 | 341 | 356 | 371 | 386 |
| 12 | 32 | 52 | 72 | 92 | 112 | 132 | 152 | 172 | 192 | 212 | 232 | 252 | 272 | 292 | 312 | 327 | 342 | 357 | 372 | 387 |
| 13 | 33 | 53 | 73 | 93 | 113 | 133 | 153 | 173 | 193 | 213 | 233 | 253 | 273 | 293 | 313 | 328 | 343 | 358 | 373 | 388 |
| 14 | 34 | 54 | 74 | 94 | 114 | 134 | 154 | 174 | 194 | 214 | 234 | 254 | 274 | 294 | 314 | 329 | 344 | 359 | 374 | 389 |
| 15 | 35 | 55 | 75 | 95 | 115 | 135 | 155 | 175 | 195 | 215 | 235 | 255 | 275 | 295 | 315 | 330 | 345 | 360 | 375 | 390 |
| 16 | 36 | 56 | 76 | 96 | 116 | 136 | 156 | 176 | 196 | 216 | 236 | 256 | 276 | 296 | | | | | | |
| 17 | 37 | 57 | 77 | 97 | 117 | 137 | 157 | 177 | 197 | 217 | 237 | 257 | 277 | 297 | | | | | | |
| 18 | 38 | 58 | 78 | 98 | 118 | 138 | 158 | 178 | 198 | 218 | 238 | 258 | 278 | 298 | | | | | | |
| 19 | 39 | 59 | 79 | 99 | 119 | 139 | 159 | 179 | 199 | 219 | 239 | 259 | 279 | 299 | | | | | | |
| 20 | 40 | 60 | 80 | 100 | 120 | 140 | 160 | 180 | 200 | 220 | 240 | 260 | 280 | 300 | | | | | | |

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| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 587 | 588 | 589 | 590 | 591 | 592 | 593 | 594 | 595 | 596 | 597 | 598 | |
| 599 | 600 | 601 | 602 | 603 | 604 | 605 | 606 | 607 | 608 | 609 | 610 | |

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# THIS WEALTH OF VITAL INFORMATION . . .

## NEW COMPONENTS

### GENERAL ENGINEERING

338—Combination Drawing Table and Desk
340—Logic Symbols Templet

### RESEARCH AND TEST EQUIPMENT

339—Temperature Recorder

### METALS AND ALLOYS

309—Enameling Steel
330—Beryllium Copper Strip

### NON-METALLIC MATERIALS, FINISHES

303—Phenolic Molding Compound
310—Heat Stable Laminate

### POWER TRANSMISSION

334—Fully Assembled Idler Sprocket

### MECHANICAL PARTS

305—Rotating Bellows Seal
335—Subfractional-hp Blower
336—Polypropylene Handle

### FASTENING AND JOINING

301—Flush-mounted Fasteners

### MOTORS, ENGINES AND CONTROLS

300—Push-pull Linear Actuator
304—Switch Actuators
306—Magnetic Timer
307—Ratio Between Rotary Speed
308—Piston Pumps and Motors
313—Miniature Magnetic Counter
314—Resistance Force Transducers
325—Electromechanical Linear Actuator
331—Single-, Double-acting Dashpots
333—Synchronous Induction Motor

### ELECTRICAL, ELECTRONIC COMPONENTS

300—Push-pull Linear Actuator
302—Contactors Mechanically Held
304—Switch Actuators
306—Magnetic Timer
307—Ratio Between Rotary Speed
310—Heat Stable Laminate
311—Plunger-type Limit Switch
312—High-speed Switching Relay
313—Miniature Magnetic Counter
314—Resistance Force Transducers
316—Electrohydraulic Servovalve
318—Encased Photovoltaic Cells
319—Solenoid Hold-down Switchlights
321—Static Relay
322—All Transistor Annunciator
323—Internally Lit Meters
324—Circular Chart Recorder
325—Electromechanical Linear Actuator
326—Subminiature Potentiometer
328—Step Variable Delay Line
329—Moistureproof Solenoid Valves
337—Ganging Potentiometer

### HYDRAULIC, PNEUMATIC EQUIPMENT

308—Poston Pumps and Motors
315—6 Ply Wire-reinforced Hose
316—Electrohydraulic Servovalve
317—3000-psi Quick-disconnect
320—High-temp Pressure Transducer
327—Hydraulic Hand Pump
331—Single-, Double-acting Dashpots
332—Relief Valves

## NEW CATALOGS AND BULLETINS

### METALS AND ALLOYS

370—Rare Earths, Thorium, 8 pp, Vitro Chemical Co.

### NON-METALLIC MATERIALS, FINISHES

358—Urethane Seals and Packings, 8 pp, Disogrin Industries
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364—Plastics for Insulating, Mechanical Uses, 16 pp, Continental-Diamond Fibre Corp.

### FABRICATION PROCESSES AND PRODUCTION

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374—Electronic Welding, 17 pp, Hughes Aircraft Co.

### POWER TRANSMISSION

350—Variable Speed Drives, 112 pp, Sterling Electric Motors, Inc.
354—Electromagnetic Clutches, Brakes, 46 pp, Autotronics Inc.

### MECHANICAL PARTS

355—Wheel Packages, 20 pp, Kelsey-Hayes Co, French & Hecht Div.
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366—Takeups, 16 pp, Link-Belt Co.
365—Miniature Bronze Bearings, 18 pp, Northfield Precision Instrument Corp.

### MOTORS, ENGINES AND CONTROLS

351—Rotary Air Products, 12 pp, Gast Mfg Corp.
372—Low Voltage Motor Controls, 16 pp, Electric Machinery Mfg Co.

### ELECTRICAL, ELECTRONIC COMPONENTS

356—Relays, 20 pp, Universal Relay Corp.
357—Gas and Vapor Electron Tubes, 12 pp, Raytheon Co.
359—Thermometers and Gages, 4 pp, American-Standard Controls Div.
361—Transistorized Indicators, 4 pp, Transistor Electronics Corp.
364—Plastics for Insulating, Mechanical Uses, 16 pp, Continental-Diamond Fibre Corp.
367—Silicon Diffused Rectifiers, 6 pp, Raytheon Co., Semiconductor Div.
368—Digital Systems Modules, 16 pp, Navigation Computer Corp.
369—Plug-in Limit Switch, 1 pp, Minneapolis-Honeywell Regulator Co.
371—Microminiature Trimming Pot, 2 pp, Edcliff Instruments, Con-Elco Div.
373—Ceramic-to-metal Components, 8 pp, Ceramics International Corp.

### HYDRAULIC, PNEUMATIC EQUIPMENT

359—Thermometers and Gages, 4 pp, American-Standard Controls Div.
351—Rotary Air Products, 12 pp, Gast Mfg Corp.
352—Valves, 6 pp, Airmatic Valve Inc.
353—Gages, 32 pp, Helicoid Gage Div, American Chain & Cable Co, Inc.
360—Hydro-pneumatic 4-way Valve, 3 pp, B-I-F Industries

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| 9 | 29 | 49 | 69 | 89 | 109 | 129 | 149 | 169 | 189 | 209 | 229 | 249 | 269 | 289 | 309 | 324 | 339 | 354 | 369 | 384 |
| 10 | 30 | 50 | 70 | 90 | 110 | 130 | 150 | 170 | 190 | 210 | 230 | 250 | 270 | 290 | 310 | 325 | 340 | 355 | 370 | 385 |
| 11 | 31 | 51 | 71 | 91 | 111 | 131 | 151 | 171 | 191 | 211 | 231 | 251 | 271 | 291 | 311 | 326 | 341 | 356 | 371 | 386 |
| 12 | 32 | 52 | 72 | 92 | 112 | 132 | 152 | 172 | 192 | 212 | 232 | 252 | 272 | 292 | 312 | 327 | 342 | 357 | 372 | 387 |
| 13 | 33 | 53 | 73 | 93 | 113 | 133 | 153 | 173 | 193 | 213 | 233 | 253 | 273 | 293 | 313 | 328 | 343 | 358 | 373 | 388 |
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| 17 | 37 | 57 | 77 | 97 | 117 | 137 | 157 | 177 | 197 | 217 | 237 | 257 | 277 | 297 | | | | | | |
| 18 | 38 | 58 | 78 | 98 | 118 | 138 | 158 | 178 | 198 | 218 | 238 | 258 | 278 | 298 | | | | | | |
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| 2 | 22 | 42 | 62 | 82 | 102 | 122 | 142 | 162 | 182 | 202 | 222 | 242 | 262 | 282 | 302 | 317 | 332 | 347 | 362 | 377 |
| 3 | 23 | 43 | 63 | 83 | 103 | 123 | 143 | 163 | 183 | 203 | 223 | 243 | 263 | 283 | 303 | 318 | 333 | 348 | 363 | 378 |
| 4 | 24 | 44 | 64 | 84 | 104 | 124 | 144 | 164 | 184 | 204 | 224 | 244 | 264 | 284 | 304 | 319 | 334 | 349 | 364 | 379 |
| 5 | 25 | 45 | 65 | 85 | 105 | 125 | 145 | 165 | 185 | 205 | 225 | 245 | 265 | 285 | 305 | 320 | 335 | 350 | 365 | 380 |
| 6 | 26 | 46 | 66 | 86 | 106 | 126 | 146 | 166 | 186 | 206 | 226 | 246 | 266 | 286 | 306 | 321 | 336 | 351 | 366 | 381 |
| 7 | 27 | 47 | 67 | 87 | 107 | 127 | 147 | 167 | 187 | 207 | 227 | 247 | 267 | 287 | 307 | 322 | 337 | 352 | 367 | 382 |
| 8 | 28 | 48 | 68 | 88 | 108 | 128 | 148 | 168 | 188 | 208 | 228 | 248 | 268 | 288 | 308 | 323 | 338 | 353 | 368 | 383 |
| 9 | 29 | 49 | 69 | 89 | 109 | 129 | 149 | 169 | 189 | 209 | 229 | 249 | 269 | 289 | 309 | 324 | 339 | 354 | 369 | 384 |
| 10 | 30 | 50 | 70 | 90 | 110 | 130 | 150 | 170 | 190 | 210 | 230 | 250 | 270 | 290 | 310 | 325 | 340 | 355 | 370 | 385 |
| 11 | 31 | 51 | 71 | 91 | 111 | 131 | 151 | 171 | 191 | 211 | 231 | 251 | 271 | 291 | 311 | 326 | 341 | 356 | 371 | 386 |
| 12 | 32 | 52 | 72 | 92 | 112 | 132 | 152 | 172 | 192 | 212 | 232 | 252 | 272 | 292 | 312 | 327 | 342 | 357 | 372 | 387 |
| 13 | 33 | 53 | 73 | 93 | 113 | 133 | 153 | 173 | 193 | 213 | 233 | 253 | 273 | 293 | 313 | 328 | 343 | 358 | 373 | 388 |
| 14 | 34 | 54 | 74 | 94 | 114 | 134 | 154 | 174 | 194 | 214 | 234 | 254 | 274 | 294 | 314 | 329 | 344 | 359 | 374 | 389 |
| 15 | 35 | 55 | 75 | 95 | 115 | 135 | 155 | 175 | 195 | 215 | 235 | 255 | 275 | 295 | 315 | 330 | 345 | 360 | 375 | 390 |
| 16 | 36 | 56 | 76 | 96 | 116 | 136 | 156 | 176 | 196 | 216 | 236 | 256 | 276 | 296 | | | | | | |
| 17 | 37 | 57 | 77 | 97 | 117 | 137 | 157 | 177 | 197 | 217 | 237 | 257 | 277 | 297 | | | | | | |
| 18 | 38 | 58 | 78 | 98 | 118 | 138 | 158 | 178 | 198 | 218 | 238 | 258 | 278 | 298 | | | | | | |
| 19 | 39 | 59 | 79 | 99 | 119 | 139 | 159 | 179 | 199 | 219 | 239 | 259 | 279 | 299 | | | | | | |
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| 587 | 588 | 589 | 590 | 591 | 592 | 593 | 594 | 595 | 596 | 597 | 598 |
| 599 | 600 | 601 | 602 | 603 | 604 | 605 | 606 | 607 | 608 | 609 | 610 |

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|---|---|
| | |
| | |
| | |

# INDEX OF PRODUCTS ADVERTISED IN THIS ISSUE

After reading the advertisements classified below . . . MORE DETAILED INFORMATION about these products can be obtained by using the attached READER SERVICE CARD.


A

Accumulators 41
Asbestos Material 35

B

Bearings
Ball 11, 50, 78
Roller 40, 50
Bellows 47
Belts, V 14–15
Bi-Metal 28
Blowers 93
Boosters 41
Brakes
Electric 36
Brazing
Alloys 46, 98

C

Castings 85–86, 89
Chains
Roller 91
Clutches
Electrical 36
Coatings 94
Cold Headed Parts 101
Controllers 25
Controls
Electrical 13
Mechanical 54
Cords 94
Couplings
Mechanical 93
Cylinders
Hydraulic 41, 45
Pneumatic 41, 45

D

Deep Drawing 32
Die Castings 94, 99
Drafting
Equipment 92
Drives
Right-Angle 101
Variable Speed 95

E

Enclosures 29

F

Fastening Methods 16, 30–31
Felt 102
Film, Plastic 10
Fittings, Hose, Pipe & Tube 47, 90
Forgings 85–86

G

Gaskets 35, 38
Gears 39
Generators
A-C 93
D-C 93
Glass 53

H

Heating Units 37
Hydraulic Fluids 56

J

Jacks 82
Joints
Universal 99

L

Lubricating Equipment 54

M

Magnesium Alloys 83
Metal Forming 29, 32
Motors, A-C
Fractional 4th cover, 34, 49, 93
Integral 4th cover, 49
Sub-Fractional 34, 49, 93
Motors, D-C
Fractional 4th cover, 34, 49, 93
Integral 4th cover, 49
Sub-Fractional 34, 49, 93
Motors, Hydraulic 43

N

Nuts 90

P

Pillow Blocks 11
Pins 30–31
Plastic Parts 88, 94
Plastics 7, 42, 44, 48
Plastics Laminated 48
Plastics Laminated to Metal 44
Power Packs
Hydraulic 94
Pumps
Liquid 2nd cover, 43, 54, 97

R

Regulators
Pneumatic 96
Relays 2, 93
Reproduction Supplies 88
Rings 85–86
Rubber-Bonded-to-Metal 98
Rubber Parts 98

S

Screws 16
Seals 3rd cover, 87
Silver Alloys 98
Speed Reducers 95
Spindles 89
Spinning 32
Steel
Coated 5
Stainless 33
Switches 2

T

Thermometers 90
Thermostats 25
Timers 2
Tubing
Seamless 96

V

Valves
Control 43, 51–52
Hydraulic 43, 51–52

W

Welding
Nuts 90
Wheels 89

Z

Zinc Coated Sheets 5




Issue of June 12, 1961
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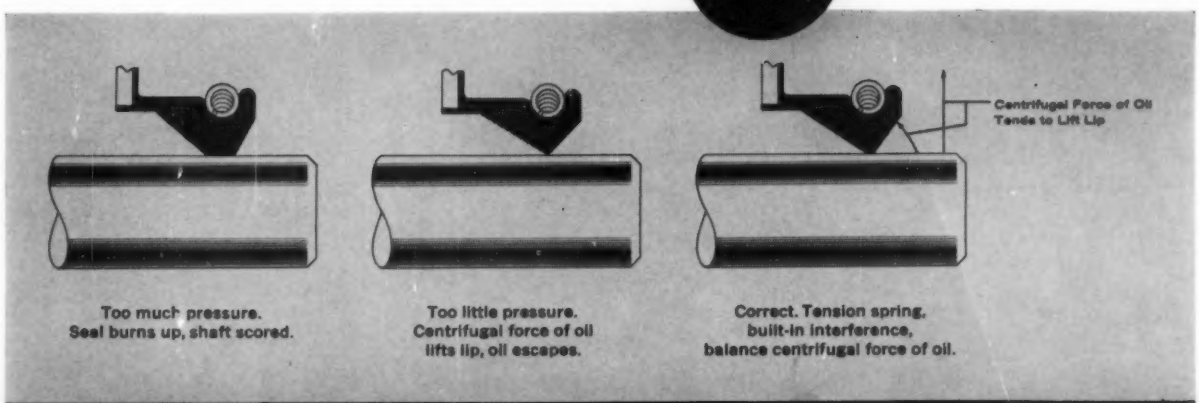
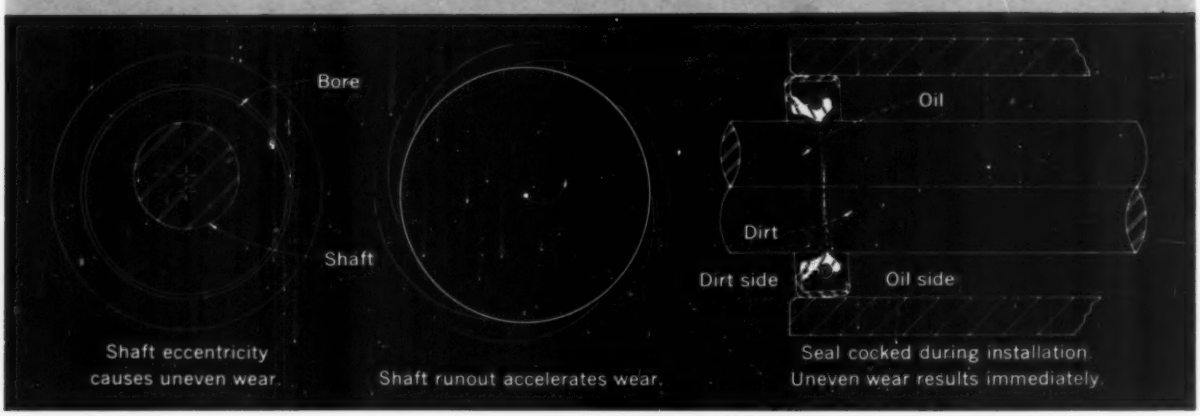
# Lip pressure...too much or too little, and you've a leaker for sure!


Centrifugal Force of Oil Tends to Lift Lip
Too much pressure. Seal burns up, shaft scored.
Too little pressure. Centrifugal force of oil lifts lip, oil escapes.
Correct. Tension spring, built-in interference, balance centrifugal force of oil.




Ideal sealing conditions are (1) shaft in bore center, (2) no runout, (3) seal not cocked, (4) seal concentric, (5) bore round and smooth, (6) shaft round and properly finished, (7) seal proper size.

Meeting these conditions is complicated, frequently requires special seal design or the specialized knowledge of National Seal engineers.

Sealing problems should be anticipated and answered on the board, not in production. Why not call your National Seal engineer now about your current project. He's in the Yellow Pages, under Oil Seals or O-Rings.

**NATIONAL SEAL**
Division, Federal-Mogul-Bower Bearings, Inc.
GENERAL OFFICES: Redwood City, California
PLANTS: Van Wert, Ohio; Redwood City and Downey, California

6860

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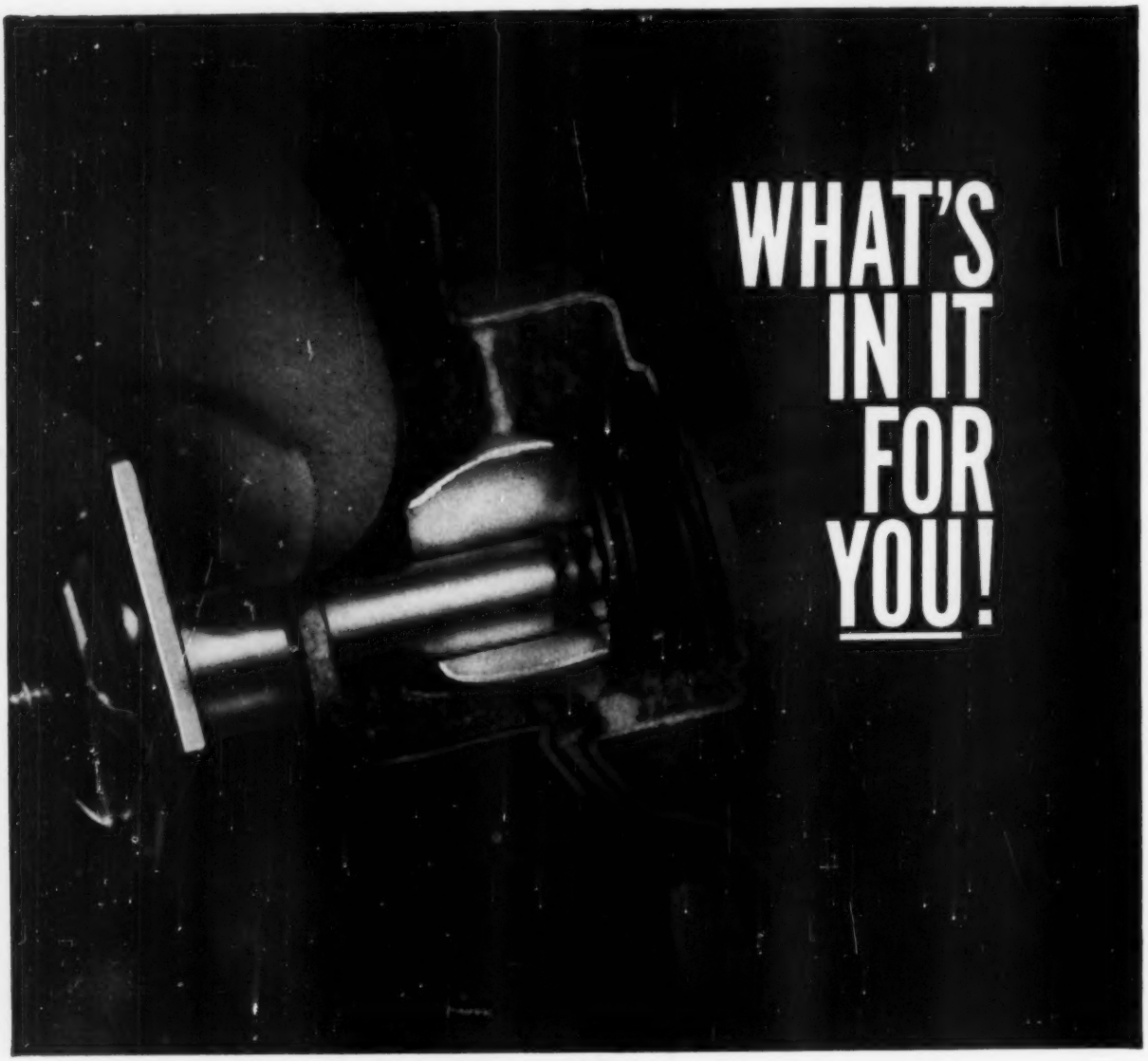
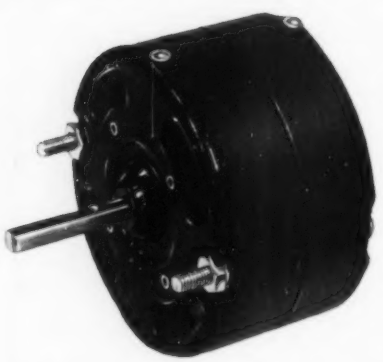



# BEARING DESIGN OF
# EMERSON ELECTRIC MOTORS

## Is Self-Oiling, Self-Aligning to assure Free Starting and Smooth Operation at all times

—The bronze bearing in Emerson Electric Motors has thousands of tiny cells that cause the bearing to act as a metal sponge and feed the shaft journal a controlled flow of lubricant. In cooling, it draws off excess oil to give free starting at low temperatures. Self-Alignment minimizes friction and greatly increases motor life when you install *Emerson Electric Motors* in your appliances and equipment. Emerson Electric Motors are custom-engineered to meet your specific needs. Call us *today* . . . you'll like our way of doing business!



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